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VEGETABLE PARASITES OF THE TEA PLANT.

THE BLIGHTS.

BY

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This is the first of a series of articles dealing with the above subject. The purely scientific descriptions of the various diseases will be omitted.

The title and the arrangement of the subject matter is that applied to chapters XIX, XX, XXI of Messrs. Watt and Mann's book on "The Pests and Blights of the Tea Plant" published in 1903 to which the writer intends to refer many times. No plates will be issued but coloured photographs of the more important diseases are being made, plates will be prepared from these and published subsequently.

The authors of "The Pests and Blights of the Tea Plant" point out that their list of vegetable parasites is by no means complete. They state that "the more important parasites may be said to be two or three fungi found on the leaves, a fungus and an alga on the stems; and two, at least, species on the roots."

Since the above paragraph was written between 20 and 30 fungi have been found attacking tea leaves, about the same number on the stems and a dozen or so on the roots. All these have received careful study. Any of these fungi may under favourable conditions cause severe damage. It is therefore necessary to keep a constant watch. Most of them individually cause little damage and in the course of our investigations it has been found that many of the attacks of fungus disease are the result and not the cause of the lack of vigour of the infected plants. The tendency of our research in more recent years has been to pay more attention to making the tea plant healthy than to curing its diseases individually. Im-

provement in the vigour of the plant unfortunately does not render it immune to all diseases and it is necessary in such cases to devise additional treatment. The direct treatment of disease is costly and the profit is more or less limited to the elimination of the loss due to the disease in question. Indirect treatment of the disease by increasing the vigour of the tea plant is far more profitable. It has been the policy of this department to limit the application of direct fungicidal treatment to those diseases which fail to respond to treatment by improving the vigour of the tea plant. The sole object in treating fungus disease is to increase the profits of tea culture by reducing the losses due to the diseases concerned. The application of a treatment which costs more than the disease is justifiable in cases where it is possible to avoid a greater loss by preventing the disease in question from attacking large areas. In the case of many of the diseases of the tea plant this is not possible as other plants outside the control of the planter harbour the same fungus. Under such circumstances it is more profitable to treat the tea plant and endeavour to improve the yield in spite of the disease. To illustrate this point let us suppose that a section of tea yielding five maunds per acre is attacked by Brown blight and the yield is reduced ten per cent. It is possible to keep the Brown blight in check by direct fungicidal treatment but the cost of such treatment would be not less than twenty rupees per acre. This amount would in many cases be more than the value of the tea saved. As the fungus which produces Brown blight is very common on other plants besides tea it would be necessary to continue the treatment indefinitely. Under these circumstances it would be more economical to spend the money on suitable manures, etc., with the object of increasing the yield. The effect of the manuring will be cumulative and although the blight may still take ten per cent. of the crop the section will yield a bigger profit. Suppose the yield is eventually increased to ten maunds per acre. As the cost per acre of fungicidal treatment would be very little more than that required for an area yielding five maunds, it would then be profitable to carry out the treatment as the in-

crease in crop would show a profit on the expenditure. It is obvious from the above that it would be foolish to issue general recommendations. It is the duty of this department to find out the life histories of the fungi concerned and by making use of this information devise methods for keeping them in check. It is also necessary to ascertain the special conditions favourable to the fungi concerned so that suggestions may be made for the modification of cultural operations such as manuring, pruning, etc., with a view to rendering the tea bush less susceptible to attack.

For reasons mentioned above it is however for the planter to make the final decision as to the advisability of carrying out the suggestions offered.

This is of course not very satisfactory to the Mycologist as it is often difficult to see how much of the improvement in the yield of a particular section is due to his researches. However, as the yield per acre of tea in North-East India continues to increase it will be increasingly possible to improve it still further by direct fungicidal operations. With this object in view considerable research has been carried out on spray fluids and methods for their application on a large scale

There are a number of more or less important vegetable enemies of the tea plant which will be taken up before those which cause "diseases."

Loranthus Sp. "ROGAMULLA."

In the forests of North-East India one frequently sees clumps of branches resembling mistletoe growing on the trees. These are also found on the tea plant particularly in the seed gardens. At the time Watt and Mann wrote they were very frequently found there but now-a-days it is only in badly neglected ones they are noticeable. These clumps are, like the mistletoe, a parasitic growth.

Rogamulla is found everywhere in the tea districts but it only causes damage on neglected seed gardens. With very

little attention it is possible to keep it in check by cutting off the infected branches. The roots of the Rogamulla extend for a long way below the point at which its leaves and stems show themselves and it is therefore necessary to cut well below this point. Various interesting things regarding this plant have been found out. The seeds do not germinate unless they have passed through a bird's intestines. The leaves of the Rogamulla are modified by the nature of the host plant. If the parasite is growing on a tree which bears narrow leaves its own leaves grow narrow. When growing on a broad leafed tree they grow broad, the shape of the leaves is even modified by the jat of the tea plant on which the parasite happens to be growing. On some jungle trees Rogamulla has been seen to replace the whole of the normal foliage but when this happens both the host and the parasite die within a few years.

Ferns and other Plants in the Bushes.

Watt and Mann point out the desirability of removing ferns, ulu grass, etc., from the middles of the bushes. This is now usually done as a part of the general routine.

Lichens and Mosses.

At the higher elevations of the Darjeeling district the tea bushes support a veritable garden of lichens and mosses. These are not parasitic but they interfere with the growth of the plant to which they are attached by offering mechanical resistance to the expansion in circumference of the stems. They also harbour insect pests. In Darjeeling the moist cool climate favours their growth and active measures for their removal are desirable. In other districts the lichens and mosses are only present to an injurious extent on bushes which owing to their poor condition make very slow growth.

Lichens are not individual plants but the result of the association of two kinds of plants—fungi and algae. For instance, in damp shady places old leaves may be observed to bear

on their upper surfaces a number of spots. The orange coloured ones of the red rust alga, black ones caused by a fungus and grey ones. The last ones are the result of the red rust alga growing in co-operation with the black fungus thus forming a lichen—which looks quite different from either. All these spots may be rubbed off the surface of the leaf. They are not parasitising it.

Remedy: Badly hide-bound plants require to be nursed back to good health by judicious manuring, pruning, etc. Their improvement may be considerably accelerated by spraying with Lime sulphur solution but the spraying alone will only effect a temporary improvement. In order to obtain permanent results it is necessary to increase the vigour of the bushes.

Except in comparatively few areas, *e.g.*, the higher elevations in Darjeeling, epiphytic plants are not now-a-days produced in sufficient quantities to warrant special measures for their removal. In Darjeeling however the application of strong Lime sulphur solution followed by rubbing with sacking, a coco-nut husk or even wire carding brushes (in extreme cases) have been used with success. Firing the section before pruning as suggested by Watt and Mann is now seldom carried out as such severe measures are not necessary.

Parasites and Blights on the Leaves.

Pestalozzia theae, Saw.

GREY BLIGHT.

Refs:—Watt and Mann, " The Pests and Blights of the Tea Plant," 2nd ed., p. 380.

Butler, Fungi and Disease in Plants," p. 451.

Petch, " Diseases of the Tea Bush," p. 27.

Indian Tea Association, "Quarterly Journal," 1920, Part IV, p. 152.

Watt and Mann give the name as *Pestalozzia guepini* Desmaz. The same fungus was subsequently considered to be *Pestalozzia palmarum*. It has, however, since been proved that the species, which normally attacks tea, is a distinct one which has been named *Pestalozzia theae*, Saw.

The disease is common in all districts.

History :—According to Watt and Mann, it was mentioned by Mr. M. C. Cooke, who examined samples from Cachar, in 1873. It has since been found in every district in which tea is grown. Even the new tea districts of Africa are not free from it. It is obvious therefore that the fungus is a very common one and although only one species has been found to attack tea that species also attacks a number of jungle plants in North-East India, *e.g.*, Nahor, *Mesua ferrea*.

Description :—Grey blight is one of the commonest blights of tea leaf. It is rarely so serious as Brown blight which it closely resembles in appearance. It usually attacks the leaves but is also sometimes found on the stem of the tea plant. The portions attacked by the fungus die forming grey patches on the upper surface. These patches when young are brown. Their edges are sharply defined by a ring of deeper brown colour and may often be marked with delicate concentric rings, alternately light and dark brown. The under surface of the leaf does not usually turn grey. The blight first appears on the upper surface of the leaf as minute brownish spots. These spots enlarge and several spots may coalesce to form one large irregular patch. Minute black dots or pustules (the acervuli of the fungus) are often seen, arranged in concentric lines, mostly near the margin of the diseased spot, on the upper surface of the leaf. Sometimes they are scattered irregularly, over both the surfaces of the spot. Some of the dots coalesce to form black crusts.

The black dots, on the diseased patches, due to Grey blight are, as a rule, much larger than those of Brown blight. Examined by a pocket lens, the dots will be seen as crater-like openings and, unlike Brown blight, are never surrounded by

any hair. A cross section of a diseased spot when examined under the microscope will show that the pustules are formed underneath the skin. The pustules arise from a collection of mycelium which develops into bowl or cone-shaped, thin walled spore cases. From the cells of the inner wall of each spore case stalks grow out and form at their tips spindle-shaped cells which are separated from the stalks by cross walls. These spindle-shaped cells, the spores of the fungus, are further divided by four cross walls into five cells, with the three central ones larger and darker than the single colourless cell at each end. The terminal cell gives rise to three or four colourless thread-like projections each ending in a blunt knob. These spores, in the course of their development, push their way through by rupturing the skin of the leaf. The spores are distributed by wind, the hair-like projections at their tips acting as floats. Experiments on the dissemination of the fungus diseases by wind and other agencies, have shown that in the air round about Tocklai, Grey blight spores are present in larger numbers than those of other common fungi attacking tea. The mycelium of the fungus grows between the cells of the leaf and within them. It is very fine and colourless and with many divisions.

Watt and Mann refer to the black dots as "*Perithecia.*" This term is now used to denote another particular type of fungus fructification. According to the nomenclature, now in common use, the clusters of spores forming the black dots are termed Acervuli, derived from the Latin word *Acervulus*—a little heap.

In another paragraph the same authors make the following observations :—

"It very often happens that these brown and grey patches "commence near the base of the leaf, and this is one of the most "alarming forms of the disease, for then the leaf will turn "brown and drop off apparently without visible blight,—for the

" fungus has only attacked the leaf stalk and extreme base of the " leaf. The attack may commence, however, on the apex, or on " the margin, or two or three patches may form at once and ex- " tend till they unite, when the entire leaf may assume a dirty " whitish grey colour.

" It seems possible that a second form of the fungus re- " producing by a different method without the intervention of " spores, may exist. A diseased leaf drops into contact with a " healthy leaf below, and where they touch become cemented by " a tuft of fungus filaments, which are the basis for a new attack. " This appearance has not yet been thoroughly investigated. It " is however, known that Grey blight is what is called a ' form- " genus,' that is to say, another and higher form of the fungus " exist, most probably living on dead leaves. The fact that such " a form probably exists renders it absolutely essential that dead " and dying leaves, whether on the bush or on the ground, " should be destroyed."

This description closely resembles that of Black rot and it is probable that this disease was confused with Grey blight.

Depredations:—True Grey blight causes little damage to vigorous tea. The epidemic form, mentioned by Watt and Mann, is almost certainly Black rot. The mistake was readily excusable as the Grey blight fungus very frequently attacks leaves which have been injured by Black rot. Where true Grey blight is prevalent, it is an indication of unsatisfactory conditions of the soil.

Remedies:—The cause of the weakness must be sought for and remedied. The blight will meantime disappear. Whenever a section of tea is badly attacked by a disease which appears to be Grey blight, no time should be lost in consulting this department as in all probability the disease is not Grey blight at all.

Glomerella cingulata, Stonem.—*Colletotrichum camelliae.*

THE BROWN BLIGHT, MASSEE.

Refs :—Watt and Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 385.

Butler, "Fungi and Disease in Plant," p. 448.

Petch, "Diseases of the Tea Bush," p. 31.

Indian Tea Association, "Quarterly Journal," 1920, Part II, p. 37.

Found in all tea districts.

History :—Brown blight was noticed here and there all over the tea districts in North-East India in 1895. It was also found in Ceylon about the same time. It has since been found wherever tea is grown.

Description :—Brown blight attacks the leaves and green stems of the tea plant. The fungus infects the leaf when it is quite young. A tiny tube from the spore enters the skin and the contents of the spore pass into one of the cells of the skin and there remains dormant until for some reason or other the condition of the leaf favours the further development of the fungus. The portions attacked by the fungus die, forming patches yellowish to chocolate brown above and light brown below. The edges of these patches are sharply defined and commonly marked with a delicate concentric zonation consisting of narrow lines and darker bands. Several spots may coalesce to form one large irregular patch. Minute black dots or pustules (the acervuli of the fungus) are seen arranged in concentric lines on both sides. On some of these spots may be seen milky or pinkish drops. These are masses of spores or seeds of the fungus. This disease is often confused with Grey blight which it resembles. The black dots on the diseased patches due to Grey blight are, as a rule, much larger than those of Brown blight, but sometimes it is difficult to distinguish these diseases without a microscope. Examined by a pocket lens these dots will be seen as crater-like openings, some of which

are surrounded by deep brownish-black hairs or papillae. A cross section of the diseased spot when examined under the microscope will show that the pustules are formed beneath the skin and later push their way through, by the development of a mass of mycelium, covered with cone-shaped erect hyphae or filaments. The end of each hypha or filament swells slightly and later is separated from the rest by a wall. The detached portions correspond to the seeds of higher plants and are called spores. This particular kind of spore is called a conidiospore. One or more conidiospores are produced from a single hypha. These spores have a gelatinous coat and they often stick together and emerge as a milky or pinkish exudation. The spores stick to insects, like red spider or green fly, cattle, the clothing of coolies, etc., and are thus distributed. They are oblong with their ends rounded, colourless, one-celled, rarely two-celled. This imperfect stage of the fungus was for a long time the only known fruiting stage. It was known as *Colletotrichum Sp.* and *Gloeosporium Sp.* When the blackish hairs mentioned above were present the fungus was called *Colletotrichum Sp.* When no hairs were found it was called *Gloeosporium Sp.* The fungus however seems to be identical. There are species of *Gloeosporium* found on tea but they have smaller spores. There are also various strains of the Brown blight fungus, some of which develop few hairs.

At a later stage the surface of the spot bearing the conidial form of the fungus becomes light grey and covered with black dots. If a section be cut across such a spot and examined under a microscope it will be seen that these black dots are the crater-like openings of spherical receptacles called perithecia. The perithecia are never surrounded by any dark hair like acervuli of the conidial form. The perithecia, produced singly or in groups, remain embedded in the tissue with their mouths only projecting. The perithecia are nearly spherical, and occasionally with short beaks. They are black. They contain a large number of club shaped sacs (asci) each of which contains eight spores. These spores are called ascospores. The ascos-

pores are one-celled, colourless, slightly tapering towards their ends and usually slightly curved. They are arranged in two rows within the ascus. The interior of the beak of the perithecia is covered with hairs. These hairs have an important function as they regulate the escape of the spores. It is most common during January to July, *i.e.*, during the cold weather and early rains.

This form of fructification is identical with that of the fungus which cause ripe rot of many fruits. This fungus has been called *Glomerella cingulata*. Stonem. The two forms often occur on the same leaf and in one case the spores of the *Glomerella* form were observed to have germinated and producing the *Colletotrichum* form. In pure culture, each form is readily produced from the other. Watt and Mann only refer to the *Colletotrichum* form but point out that another form is probably produced in decaying leaves.

Depredations :—This blight only attacks leaves which have been weakened by other causes. Brown blight is sometimes very serious indeed and the loss in crop due to a severe attack is very considerable. It is more commonly serious on unpruned than pruned tea and is frequently one of the causes of disappointing yields especially when weather conditions are unfavourable, either too dry or too wet. It only causes serious damage on weak bushes. In some districts notably the Dooars and Terai it is one of the commonest diseases and in conjunction with other fungi and insect pests causes considerable loss. No case has been observed in which Brown blight alone may be said to have caused the damage. It is almost invariably associated with red rust and frequently with species of *Corticium* also.

Remedies :—As the disease is always associated with lack of vigour in the infected bushes and the fungus which produces it is a very common one, it is obvious that direct fungicidal treatment will only have a temporary effect. The most reasonable way to deal with attacks of this disease is to ascertain the cause of the weakness of the bushes and remedy that.

There are cases, however, where Brown blight and other diseases associated with the weakness of the bush are so severe that it is necessary to apply direct fungicidal treatment to check the diseases, sufficiently to allow the bushes concerned to take advantage of improved conditions within a reasonable time. It should, however, be emphasized that the direct fungicidal treatment of Brown blight is mere waste of money if the conditions, responsible for lack of vigour of the bushes, are not dealt with also.

Spraying with Lime sulphur solution, see Quarterly Journal, Part IV, 1926, has been proved to be a satisfactory method of checking this disease. On account of the cost, both in money and labour, spraying is only recommended when the attack is so severe that the improvements, in manuring, pruning and cultivation, are not likely to produce the desired effect, unless the disease is checked. On many gardens in the Dooars and the Terai districts Brown blight, in association with other diseases, is causing such severe damage that the bushes fail to respond to cultural improvements. In such cases spraying with Lime sulphur solution is recommended even where the immediate addition to the crop does not cover the cost. It may even be necessary to continue the spraying at a loss for some years, until the cultural improvements have increased the vigour of the bushes sufficiently to enable them to withstand the attacks of the disease.

There are cases where for some reason or other spraying is impossible. In those circumstances the loss to the plant due to the diseases can be compensated for by allowing it to grow more leaf. In other words by leaving it unplucked after pruning and manuring. Some planters hold the erroneous opinion that the same effect can be produced by leaving the bushes unpruned. Observations have shown that this is not the case. The removal of much of the diseased and moribund wood tends to strengthen the bush if it be allowed to remain unplucked. In most cases the desired result may be obtained by manuring

and pruning the bush and leaving it unplucked for one year. In extreme cases it may be necessary to leave it unplucked for a second year. The bushes should always be pruned again at the end of the first year and needless to say the manuring should be continued indefinitely.

Rim Blight.

Refs :—Watt and Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 386.

Butler, "Fungi and Disease in Plants," p. 455.

Petch, Diseases of the Tea Bush," p. 39.

Indian Tea Association, "Quarterly Journal," 1916, Part II, p. 85, and 1918, Part II, p. 27.
1918, Part II, p. 27.

Found in Upper Assam.

History :—This disease was first mentioned in the first edition of "The Pests and Blights of the Tea Plant" published in 1898. In the second edition it is attributed to the combined attack of the fungi which cause Brown and Grey blights. Later the writer attributed it to species of *Alternaria* and *Cladosporium*. Various other fungi have also been found in association with this disease.

Description :—The blight first appears on the young leaves. The serrations turn brown. As the leaf grows the browning extends inwards and as the portions remaining green continue to grow the leaf becomes wrinkled with the edges curled downwards. In the meantime the brown portion continues to extend until finally most of the area of the leaf dies. When the attack is severe all the young growth may be destroyed. The blight is only found on the young succulent growth produced early in the season. It has never been observed at other times of the year.

Recent researches have shown that the attacks of fungi are not the cause but an effect of the disease. In the early stages the dead tissue is quite free from fungi. Examination of the

stems and roots of the bushes on which the disease appears has revealed the presence of no fungus or other parasite likely to account for the condition.

The disease is serious only on light leafed varieties of tea. Investigations show that at the same time the disease appears on the light leafed varieties the growth of other varieties in adjoining sections is also checked although the disease does not attack them. It appears that the disease only occurs when in the early part of the season a period of good growing weather is succeeded by a period of bad growing weather. The weather may be either too dry or too wet. The blight is more serious on cut back or heavy pruned than on light or unpruned tea.

Depredations :—A bad attack of the disease may cause the loss of all the new growth. When the weather conditions improve the growth is gradually renewed and by July or August no trace of the trouble is usually noticeable.

Remedies :—As the disease is the result of climatic conditions it is impossible to do much when a section is actually attacked. If, however, experience shows that certain sections of tea are particularly liable to attack something may be done to prevent recurrence. It has been found by experience that shade reduces the tendency to attacks of this disease but it takes some years to establish shade trees. In the meantime it is possible to avoid the production of very succulent leaf at the time of the year when the weather is usually very uncertain. This may be done by carrying out cutting back and heavy pruning very late in the cold weather. It is questionable however whether the loss due to the lateness of the pruning will not be just as great as that due to the Rim blight. The recovery from Rim blight may be accelerated by manuring with readily available manures immediately the disease appears. Nitrogenous manures appear to be particularly suitable for this purpose.

THE MANUFACTURE OF GREEN TEA.

BY

C. J. HARRISON.

There are several gardens in North-East India on which the manufacture of green tea is carried out during the whole, or part, of the season. The entire exclusion of the withering and fermenting stages necessary to the manufacture of black tea, renders the whole process of manufacture of green tea a simple one in comparison with that of black tea, variations in weather conditions exercising little effect on the manufacture of the former type of tea.

While this is so, green tea making requires as much, if not more, care and supervision than does black tea manufacture, since the plea of unfavourable weather conditions cannot be advanced as an excuse for poor quality of the unfermented product.

Theory. The theory of the manufacture of green tea is as follows :—

In the modern process the tea leaf undergoes a process of steaming whereby all the chemical changes connected with withering and fermentation are checked. These changes ordinarily go on under the influence of complex substances called enzymes, and it is the destruction of these latter in the steaming process which prevents the wither and fermentation from taking place. The succeeding processes of centrifuging, rolling, drying, and sorting are, so far as can at present be ascertained, connected with no chemical change and merely bring the leaf into a suitable condition for the market. It will be realised, that, with the om-

mission of the withering and fermenting processes, the time taken in manufacture, from the time the leaf comes into the factory to the time it leaves the dryer after the final firing to 16 annas, is scarcely more than two hours, as against an average of 24 hours for the manufacture of black tea.

Type of leaf required.

Since mechanical stalk extracting is a very difficult process to carry out satisfactorily on green tea, it is essential that good quality leaf with small shoots shall be plucked. Leaf attacked by red spider or mosquito shows up clearly in the infusion as red or discoloured leaf, and as such, detracts considerably from the value of the tea, which should give a completely green infusion.

The practice of pressing down the leaf in the plucking basket or in leaf gharries is a bad one and should always be discouraged since it causes the leaf to heat up, and results in reddening. This reddening is a sign of chemical withering having taken place and in consequence the liquors of the leaf made may have an orange or reddish appearance. In addition the infused leaf is reddish. Such teas command much lower prices than those giving bright green infusions and pale greenish-yellow liquors.

Often the evening leaf is not manufactured at once but is spread about 6 inches deep in a cool place, *e.g.*, on the floor of the fermenting room (which will be out of use at the time, if black tea is not being made). As early as possible next day, this leaf is steamed and manufactured. If, as often happens, the night has been hot, some withering takes place, and teas made from leaf kept overnight are poorer in quality than teas made from leaf manufactured immediately. Much can be done to arrest any withering while the leaf is on the floor of the fermenting house, by spraying it with clean water. For this purpose, ordinary garden sprayers or syringes with fine nozzles are very convenient. If the leaf comes in saturated with rain water as a result of a heavy shower before or during plucking, spraying need not of course be resorted to.

During the middle of the rains, when the quality of black teas is at its poorest, the quality of green tea should be at its best, the humidity of the atmosphere preventing, to a great extent, any withering likely to take place before the steaming operation. Moreover, the leaf on the bush gets more shade during the rains, when not only are shade trees in full leaf, but the weather is naturally more cloudy. This excess of shade produces better quality of leaf for green tea, and the final product has a deeper green colour.

Processes of manufacture.

The first operation, namely steaming, is carried out in a cylindrical drum of wood or metal, rotating on its longer axis at about 15 r. p. m. The charge is about 200 lbs. of green leaf, and the length of time each charge is steamed—is from 2 to 3 minutes. Steam at 20—30 lb. sq. in. pressure is led into the drum at either end, the steam pipes forming the spindles on which the drum rotates. As each charge is finished it is emptied out on to the floor and cooled with cold water. Two charges, *i.e.*, 400 lbs. of green leaf, are then put into a centrifugal machine, or hydro-extractor, revolving at about 1,000 r. p. m., and a considerable quantity, about 15 gallons, of yellowish liquid is expressed. This liquid contains about ½ lb. per gallon of solid matter, of which 2½ ozs. is tannin and ½ oz. is caffeine.

After centrifuging for about three minutes the leaf is removed and rolled with no pressure.

The length of time of this roll varies in different factories from ten minutes to half an hour. After rolling, the leaf is put through a dryer, and dried off to a degree which varies considerably in different factories. In some factories it is dried only to about six annas, and in others to a degree just short of crispness. The semi-dried leaf is rolled again and kutcha sifted. A suitable scheme for rolling is 20 minutes medium pressure with a kutcha sift, then 40 minutes medium heavy pressure followed by another kutcha sift to break up the balls of leaf.

The leaf is then dried either in one or two operations. In one factory the drying is done in a Gibbs and Barry machine at 180°F making 4—5 r. p. m.

In another, the drying is completed in two operations, the first in an Empire at 220°F. to 12—13 annas, and the final one also in an Empire at 200°F. to 16 annas.

The "rough mal" is a dark olive green colour and stalk shows up almost white. This is picked out by hand from the cut mal, as the use of a mechanical stalk extractor causes flakiness, and gives, instead of twisted grades, a large percentage of a grade similar in appearance to the Souchong of black tea. Such a grade is undesirable and would get only a low price in comparison with well twisted Hyson.

After sorting, the teas are in some factories given a polish by placing the tea in a narrow cylindrical iron drum with 1 per cent. of French Chalk, and rotating the drum for about two hours. This process is also called "glazing" or facing." In some factories, especially those who make teas for the American market, "facing" is left out, the teas being sent away without any polish.

A few years ago the polish used often contained Prussian Blue and turmeric in addition to French Chalk or soapstone, to improve the colour of the tea; this practice however is now generally discarded as the constituents of the polish are considered harmful.

The following are typical green tea grades :—

Fine Young Hyson; Young Hyson; Hyson No. 1; Hyson; Twankay; Fannings or Soumée; and Dust.

In one or two gardens, the Hysons are combined into one grade called Young Hyson, which forms about 90 per cent. of the invoice. The remaining 10 per cent. is made up of 2

per cent. Twankay, 3 per cent. Fannings, and 5 per cent. Dust. The following tables show tannin and caffeine percentages in typical green teas :—

	Grades.	Percentage made.	Total Tannin.	Total Caffeine.	Tannin in Taster's infusion.	Caffeine in Taster's infusion.	Moisture.
	South Sylhet Garden.						
A	Young Hyson ...	90¼ %	13·87 %	3·42 %	7·9 %	2·71 %	5·2 %
	Twankay ...	1¾ %	12·99 %	1·46 %	......	......	8·4 %
	Fannings ...	2¾ %	15·90 %	1·40 %	......	......	8·9 %
	Dust No. 1 ...	5¼ %	16·82 %	2·20 %	......	......	8·0 %
B.	Young Hyson ...	85–90 %	13·69 %	1·83 %			5·2 %
	North Cachar Garden.						
	Young Hyson ...	12½ %	14·09 %				
	Fine Young Hyson	12½ %	11·85 %				
	Hyson No. 1 ...	25 %	13·23 %				
	Hyson ...	33 %	15·29 %				
	Twankay ...	14 %	12·89 %				
	Dust ...	3 %	14·09 %				

Comparison with black teas.

The total tannin in green tea is always higher than that of black tea made from similar leaf. The reason is that, during the fermentation of black tea, a certain percentage of tannin is converted into red and brown substances, some of which are not extracted by hot water and remain on the leaf, to give it the characteristic reddish brown colour. The longer the fermentation and the warmer and dryer the fermenting room, the greater is the production of insoluble brown substances, and therefore the lower is the tannin content of the final product.

This loss of tannin is not undergone in green tea manufacture since there is no fermentation, and a high tannin content in the final product results, the only loss being due to expression of juice in the hydro-extractor.

With regard to caffeine, there is no apparent reason why black and green teas should differ, but it is usually found that green teas contain more of this stimulating substance than do black teas.

In a cup of black tea there is little less tannin than in a similar infusion of green tea, but whereas in the former case some of the tannin is in the form of reddish brown, tasteless substances, we find in green tea liquors all the tannin in the form of astringent colourless tannin. The caffeine extracted in a cup of green tea is always considerably higher than that extracted in a cup of black tea.

The following figures compare total percentage of caffeine and tannin in black and green teas, and also the percentage of these products extracted in an ordinary taster's infusion.

Percentages of tannin and caffeine.

Black tea—B.O.P.				Green tea—Young Hyson.			
Total.		Extracted in a taster's fusion.		Total.		Extracted in a taster's infusion.	
Tannin ...	13·0%	Tannin	7·20%	Tannin	13·9%	Tannin	7·9%
Caffeine ...	2·5%	Caffeine	1·20%	Caffeine	3·42%	Caffeine	2·71%

Quality of Leaf and Liquor.

The leaf of green teas should be olive green with no trace of brown or red colour. There should be an absence of white or yellowish stalk. The grade should be even in size, well twisted and clean, *i.e.*, free from dust. Buyers for markets, such as the Kashmir market, attach much importance to the appearance of the leaf and generally prefer polished teas. For such markets the liquors are of less importance than the leaf appearance.

Liquors should be greenish yellow or lemon yellow, with no suspicion of redness, due to withering or fermentation having taken place. The liquors should be pungent or "piquant" and should remain quite clear when cooled down. The case is

directly the opposite with black tea liquors, which should "cream down" when cool. The infused leaf should be green with no suspicion of redness due to withering, fermentation or to discolouration of the leaf by red spider, mosquito or mechanical damage.

It is interesting to note that the weight of tea made from a given weight of leaf is less in the case of green tea than in the case of black tea.

One maund of black tea requires four maunds green leaf.

One maund of green tea requires five maunds green leaf.

It is difficult to account completely for this loss in making green tea, though much of it is due to the extraction of soluble solid matter in the juice which is centrifuged off after steaming.

References.

"Green Tea" by Chas. Judge.

"Tea in China" by Samuel Ball.

THE TEA RESEARCH INSTITUTE OF CEYLON.

The first Annual Report, recently published, of this newly established Experiment Station, makes interesting reading.

The Institute came into being at the beginning of March, when the Director took up his duties. Since then, three other officers have been added to the staff, an Entomologist, a Mycologist, and a Biochemist, while it is hoped to add an Agricultural Chemist to the staff shortly. As regards scientific officers, therefore, this Institute is already in the position to which our own Scientific Department had advanced when the Tocklai Experimental Station was opened in 1912, twelve years after the inception of the Department.

The Report states that difficulty is being experienced in obtaining a suitable site for an Experimental Station, and at present the staff is working in temporary quarters. In spite of this handicap, however, the Report indicates that a determined and successful effort has been made to initiate a comprehensive programme of work on both the culture and manufacture of tea, while the number of enquiries and specimens received from estates, in what was virtually the first half-year of the existence of the Institute, shows the interest taken in the venture by the planters in the island, and must be a matter of considerable satisfaction both to the staff and the Board of Control.

The Director, in reviewing the needs of the Tea Industry as regards scientific enquiry, emphasizes the need for investigation into the physiological processes of the tea bush. In this connection he makes a statement which might very well be turned into a "slogan," printed on cards, and hung in a conspicuous position in the office of every tea estate :—

THE TEA BUSH IS THE BASIS OF THE TEA INDUSTRY.

In the multitude of problems which confront the modern planter this axiom is apt to be overlooked.

The most serious problems demanding investigation in Ceylon, according to the Director, are those connected with pruning, and it is not difficult to see how this may very well be. In North-East India, except in the hill districts of Darjeeling, the general practice is to prune every cold weather. Of late years, for various reasons, considerable areas of tea have been left unpruned for a year, and one effect of this practice which has already made itself apparent is a slackening of the control on the condition of the bush exerted by the annual pruning.

In a district such as Ceylon, where it has been the custom, for years, to prune at very distant intervals, this slackening of control must have gone much further, and it is not surprising to find that now that the light of scientific enquiry has been focussed on the Ceylon tea bush the necessity for investigation into pruning methods is thrown into relief.

The Director of the new Institute is a mycologist of distinction and extensive Ceylon experience. The Mycologist is an officer who has already spent some years in the investigation of fungus diseases of tea and other plants in Ceylon, as a member of the staff of the Agricultural Department. The Entomologist and Bio-chemist are younger men, new to the island. It might therefore be expected that in the early stages of the Institute, at any rate, the reports will deal more fully with the mycological problems. This is the case with the first report, and the Mycologist submits an account giving interesting information on the Cercosporella Leaf Disease, Chlorosis of Tea, Branch Canker, and Diseases of Tea Seedlings.

The Cercosporella leaf disease is found on tea in North-East India, but the damage caused thereby is negligible. It is occasionally found on bushes growing on patches of unsatisfactory soil and is usually associated with Red Rust, Brown blight and Grey blight. It has been found in North-East India that this disease disappears when soil conditions are improved. The Ceylon Mycologist remarks that in Ceylon the disease is common only when the conditions are very humid. In our own tea districts the disease is only noticeable during spells of rainy.

weather early in the season. When the rains set in it usually disappears, sometimes reappearing towards the end of the season.

The next reference in the report is to "Chlorosis of Tea." The Mycologist refers to a description of a disease described by Mr. Park, Assistant Mycologist to the Ceylon Department of Agriculture, as "Witches' Broom." This disease apparently resembles that known as "Apple foliage blight" in Upper Assam, but differs from it in two important points. In Ceylon the leaves become mottled with yellow, sometimes becoming quite yellow. This yellowing is not noticeable in "Apple foliage blight." In many cases indeed the leaves assume a darker colour than normal. Mr. Park also mentions abnormal branching in the Ceylon disease. This has not been observed in North-East India. The Mycologist points out that there may be three distinct diseases described as one disease by Mr. Park, tufted branches or Witches' Broom being characteristic of one, yellow and dwarfed leaves of the second, and the abnormal branching of the third. In order to avoid confusion on these points he suggests that the name "Chlorosis" be used only for the disease of which the yellowing of the leaves is the most prominent character. Chlorosis of tea occurs in fairly well defined areas in Ceylon and causes a very great diminution in crop and the death of a large proportion of bushes. In this disease the leaves become mottled and finally yellow. No organism was observed on the tissues. The disease does not appear to attack young plants and rarely makes its appearance before the bushes have been centred. It was observed that the acidity of the cell sap of the diseased stems and leaves was distinctly lower than that of normal stems and leaves. Experiments to determine whether the disease is infectious have been started and some very interesting results may be anticipated. No similar disease has so far been observed in North-East India, and Apple foliage blight, which may be the same as "Witches' Broom," is uncommon. It appears to attack only bushes of the Assam Indigenous jat and then only isolated specimens. It does not appear to be associated with soil conditions and does not appear to spread. One

specimen was watched for many years and none of its neighbours showed signs of attack. This specimen was sprayed, manured, pruned, etc., etc., without effecting any improvements in its condition. It was finally replaced and its successor is doing quite well. The only way of dealing with cases of Apple foliage blight in North-East India appears to be the removal and replacement of the bush concerned.

In connection with Branch Canker it is pointed out that the fact that organisms are present in decaying tea wood is no proof that they cause the decay. So far no two tea estates have yielded the same fungi, but the evidence at present available indicates that in the great majority of cases infection by organisms which leads to the rotting of tea wood occurs at the pruning cuts. A discussion on the use of antiseptics for the prevention of infection follows, and it is pointed out that the object of applying antiseptics such as tar is solely to prevent infection. It is not intended to encourage healing. The healing process is one of growth for which food material is required. Healing starts from the edges of the wound. The last part to be covered is the centre. The rot usually starts from the centre. For this reason the wound must be protected against invasion until the normal healing callus can cover it. Effective prevention of wood rot in tea necessitates two distinct processes :—

1. The encouragement of healing by the application of suitable fertilisers and by the accumulation of food reserves within the plant before pruning.

2. The protection of the wounds by suitable antiseptic covers which will prevent the entry of rotting organisms until the wounds can be healed by the natural process.

From the statements made in this report it would appear that the pruning cuts do not heal so readily in Ceylon as they do in North-East India. This may be due to the Ceylon system of pruning. In our tea districts stem-rotting fungi cause serious damage only on old tea which has been cut back severely. The damage is reduced very considerably by :—

1. Preparing the bushes before pruning by manuring.

2. Allowing the bushes to produce ample growth following severe pruning. On some sections it has been found desirable to leave the bushes unplucked for a year following heavy cutting back. Where this has been done the cuts have healed very satisfactorily without any special antiseptic treatment, and the loss in crop in the first year is then more than compensated for by the extra leaf obtained in subsequent years.

By careful management it is possible to reduce to a minimum the necessity for pruning severely, but for a number of years to come, even in North-East India, it will in certain cases be necessary to cut back on to old hard wood, and a satisfactory antiseptic for application to the cuts would be a boon. So far nothing really satisfactory has been found.

The report then deals with seedling diseases. The Mycologist points out that in order to deal with many of the diseases associated with tea seedlings it is necessary to have a greater knowledge of the optimum conditions for the growth of the host plants. Chemical and physical analyses of soils provide insufficient data and considerably more attention must be given to the physiological condition of the plants themselves. Some experiments of a purely physiological nature have been initiated.

In our own tea districts it has been found repeatedly that improvement in the condition of the tea bushes brought about by improving soil conditions, pruning, etc., has overcome disease. In the course of time, as our knowledge of the conditions favourable to the growth of the tea plant is increased, it will in all probability be found possible to reduce the damage done by most of the fungus diseases to a negligible quantity.

The physiological investigations undertaken by the Mycologist therefore promise results of great interest and importance.

The Report of the Biochemist, who had been in the island only four months or so when the report was issued, deals mainly with preliminary work necessary to get his laboratory into working order and to test the value of different experimental

methods, but observations are already being made to determine the seasonal changes in the composition of the tea leaf, and the effect of withering on its water-soluble constituents.

An interesting section of the report, to those acquainted with the insect pests of tea in North-East India, is the section contributed by the Entomologist, affording evidence, as it does, that the main problems confronting the tea entomologist in Ceylon are very different from those he has to deal with in North-East India.

There is, for example, no mention of the tea mosquito bug, thrips, green-fly, looper, red slug, or of any related insect, while red spider only obtains casual mention. Thus few of our most important insect pests appear to be troublesome in Ceylon, while those most troublesome in Ceylon are of less importance here. Termites form an exception, being troublesome in both countries, but as it is stated in the report that the study of those insects is being undertaken by the Government Entomologist, their omission from the report is explained.

Tea tortrix, a pest of little moment here, is severe in Ceylon, and, although not perhaps so intense in its attacks as formerly, is gradually spreading over a large area, and also extending its range of food plants.

Shot-hole borer, a serious pest in Ceylon, but unknown in North-East India, is gradually receding in importance owing to the adoption of appropriate manurial treatment of the affected bushes.

Nettle-grub outbreaks occur locally, as in North-East India. Parasitisation by ichneumons appears to keep them in check, as is often the case in our districts.

The role played by red spider in North-East India would appear to be taken, in Ceylon, by the scarlet mite, though the purple mite is apparently more widely distributed. Yellow mite is abundant locally, but of minor importance.

Brown bug, lobster caterpillar, and a small bagworm are also recorded, and also, which is of considerable interest, the common Albizzia caterpillar, Terias silhetana. This latter caterpillar, with which is associated, less commonly, Terias hecabe, is very common in North-East India, and occasionally causes great damage to green crops, dhaincha (*Sesbania aculeata*) in particular. One case occurred in which 30 acres of dhaincha were entirely eaten down in three weeks. So far, however, perhaps fortunately, it has not, in North-East India, turned its attention to tea.

The red borer is described in this report as a nursery pest. It would hardly be described as such in North-East India, for although found in nurseries which are left for two or three years to obtain large plants for infillings, the practice of planting out at six and twelve months old generally results in the nursery being removed before the plants are big enough to support the insect. In clearances, however; it is occasionally a serious pest. It is by no means uncommon, however, in old tea. Cutting back the affected stems, with prompt destruction of the grubs, is reported to be an effective control, and this is also the case in North-East India. The important point is to cut out the affected branch as soon as possible after the leaves show that it is dying. Delay gives the grub a chance to become mature and escape.

Cutworm is a nursery pest in Ceylon, as in North-East India. Results are given of control experiments with attractive baits, which indicate that sweet potato and cabbage leaves, placed in pits in the soil, may be of value as traps for those insects.

Eelworm is occasionally serious in nurseries, and experiments on control have been instituted.

This section of the report concludes with notes on various pests of Dadap, Albizzia, Gliricidia, and Boga medeloa.

A catalogue of the books and periodicals in the Library completes a report which affords every indication that tea in Ceylon is to be well served by its new Research Institute.

THE FIELD EXPERIMENTS AT TOCKLAI.

BY

E. A. ANDREWS.

No. 4. THE PLUCKING EXPERIMENT.

In a previous number of this Journal* a report was published dealing with the results obtained in this experiment to the end of the season 1924.

The present report deals with the observations made from that date to the end of 1926. The records of the yields have been continued, but in addition, during the two years under review, the prunings from five bushes in each line (bushes No. 2 to No. 6) have been carefully measured with a micrometer at the point of severance, and the diameters recorded, in order to obtain a measure of the thickness of the pruning wood obtained.

It had been intended, as mentioned in the previous report, to distinguish between prunings from the centre and sides of the various bushes, but this was found to be impracticable.

The shoots to be measured numbered several thousands, and it was soon observed that unless all were thoroughly dried before being measured errors of some significance would creep in. It was therefore necessary to spread the bundles of prunings in the sun for some months before taking the measurements. In order to have an estimate of the amount of shrinkage on drying, six shoots from each bundle were measured immediately, and again at intervals until thoroughly dry. It was thought that in this manner a correcting factor might be obtained to enable the diameter of the fresh prunings to be calculated from the measurements of the dry prunings.

In the tables included in this note the diameters given for prunings collected in 1925 and 1926 refer to the dry prunings,

* 1925, Part I, pages 12 to 24.

for the reason that the shrinkage of the shoots in drying was found to be extremely irregular. The percentage shrinkage of prunings collected in 1925 varied between 2 and 23, while that of prunings collected in 1926 varied between 5 and 56. It was therefore obvious that a figure obtained from six shoots could not be used as a correcting factor for the whole bundle, and the measurements of the dry prunings have been utilised for comparison.

This variation in the amount of shrinkage undergone by different shoots in drying is of some interest, and it is curious to note the high degree of shrinkage of prunings cut from the bushes in the cold weather of 1926, as compared with those cut from the bushes at the end of 1925.

Table I records the yields of the plots, calculated to maunds of made (pucca) tea per acre, for the years 1925 and 1926, and the total average yield of the bushes under each experimental treatment.

In this and succeeding tables the same abbreviations have been used as in the previous report, but for ready reference they are here explained.

6 means plucked to six inches, and then to a janum throughout the season.

6L means plucked to six inches, and then to a leaf throughout the season.

4L means plucked to four inches, and then to a leaf throughout the season.

BB + means broken back to the janum or leaf, as the case may be.

BB – means not broken back.

BJ + means that banjhies were plucked (one leaf being weighed and the rest thrown away).

BJ — means that banjhies were left on the bush.

TABLE I.

Yields in Maunds of Made Tea per acre.

Treatment.			Line.	1925 Yield.	1925 Average Yield.	1926 Yield.	1926 Average Yield.	Total Average Yield to date.
B	B.	B J.						
6	+	+	10 19 28	10·7 10·2 8·[illegible]	9·8	9·6 10·5 9·8	10·0	67·1
6	−	+	3 12 21	12·1 11·7 11·3	11·7	8·0 8·2 10·9	9·0	67·5
6	+	−	2 11 20	11·4 10·7 9·8	10·6	9·5 8·4 9·2	9·0	59·0
6L	+	+	6 15 24	9·8 8·3 8·8	9·0	8·3 8·3 8·8	8·5	53·2
6L	−	+	4 13 22	9·7 10·9 7 5	9·4	7 0 7·0 7 8	7·4	52·4
6L	+	−	5 14 23	8·8 8·5 7·5	8·3	8·5 8·5 9·2	8·7	16·[illegible]
4L	+	+	9 18 27	9·8 8·5 8·2	8·8	10·4 10·5 8·5	9·8	59·4
4L	−	+	7 16 25	9·1 8 5 9·2	8·9	8·6 8·8 9·5	9·0	53·9
4L	+	−	8 17 26	9·5 9·5 7·5	8·8	7·3 7·5 9·5	8·1	49·1

Table II records the diameters of the dry prunings at the point of severance, all prunings from each bush being measured and the results averaged, and the means of the averages for the three lines receiving similar treatment being then calculated.

TABLE II.

Thickness of the Pruning Wood.

Treatment.	Line.	1925 Average diameter of prunings in inches.	1925 Mean diameter in inches.	1926 Average diameter of prunings in inches.	1926 Mean diameter in inches
B. B. B. J. 6 + +	10 19 28	·195 ·191 ·218	·201	·216 ·248 ·225	·230
6 − +	3 12 21	·199 195 ·225	·206	·220 ·247 ·234	·234
6 + −	2 11 20	·198 ·209 ·214	·207	·228 ·242 ·240	·237
6L + +	6 15 24	·205 ·193 ·216	·205	·250 ·240 ·225	·238
6L − +	4 13 22	·224 ·218 ·212	·218	·254 ·244 ·260	·253
6L + −	5 14 23	·210 ·226 ·231	·222	·257 ·242 ·256	·252
4L + +	9 18 27	·199 ·212 ·238	·216	·229 ·250 ·248	·242
4L − +	7 16 25	·243 ·217 ·225	·228	·220 ·237 ·231	·229
4L + -	8 17 26	·227 ·197 ·244	·223	·245 ·250 ·235	·243

The results will be discussed in a manner similar to that followed in the previous report, taking first the effect of the class of plucking on the yield of leaf and thickness of pruning wood, next the effect of breaking back, and then the effect of taking "banjhies."

The Effect of the Class of Plucking.

Table III gives the total yield to date in maunds per acre given by the three different classes of plucking, and the mean diameter of the pruning wood in 1924, 1925, and 1926.

TABLE III.

The effect of the different classes of Plucking.

Class of Plucking.	Yield to date in Maunds of Made Tea per acre. (1921–1926 inclusive)	Mean diameter of pruning wood in inches.		
		1924	1925	1926
6	64·5	·229	·205	·234
4L	54·1	·233	·222	·238
6L	50·3	·242	·215	·248

If this table be compared with the corresponding table in the previous report it will be observed that the yields, under the different systems of plucking, still maintain the same order. Plucking to six inches, and then to the janum throughout the season, has given the highest yield; while plucking to four inches, and then to a leaf throughout the season, has yielded more than when, with similar treatment, the initial plucking left six inches of new growth. That these differences are not due to the fact that they existed in 1924, while the yields have since been even, is shown by the total yields for 1925 and 1926, which are as follows :—

6	—	20.0	maunds of	made tea	per acre
4L	—	17.8	,,	,,	,,
6L	—	17.1	,,	,,	,,

At the same time, it will be noticed that plots 6L are now yielding practically the same as plots 4L, and if the yields for 1924, 1925 and 1926 be compared with those for 1921, 1922 and 1923, it will be observed that plots 6L have yielded more leaf, relative to plots 6, during the last three years than during the

first three years. The increase, however, did not occur gradually, but suddenly in 1924, and its significance is as yet doubtful.

The figures for the thickness of pruning wood show that in 1926, as in 1924, the thinnest wood was obtained on the bushes plucked to six inches, and then to the janum, and the thickest wood on those plucked to six inches, and then to a leaf. The figures for 1925, however, do not show this, as the thickest wood was obtained on the bushes plucked to four inches and then to a leaf.

Reference to Table IV, however, shows that in 1925 the bushes plucked to four inches and then to a leaf gave, for some reason, an unusually low yield, falling to, if not below, the level of those plucked to six inches and then to a leaf.

TABLE IV.

The Effect of the different classes of Plucking.

Class of Plucking.	Year.	Yield in Maunds of Made Tea per acre.	Mean diameter of pruning wood in inches.
6	1924	9·9	·229
	1925	10·7	·205
	1926	9·3	·234
4L	1924	8·4	·233
	1925	8·8	·222
	1926	9·0	·238
6L	1924	8·2	·242
	1925	8·9	·215
	1926	8·2	·248

Thus the indication, afforded before, that thickness of pruning wood is correlated with the amount of leaf removed from the bush, rather than with the style of plucking adopted, is emphasised.

Those who perused the first report will remember that each experiment is triplicated, there being three series of bushes re-

ceiving each treatment. Table V gives the yield to date for each series, and it will be seen that the differences in yield observable on examining the effect of each treatment as a whole are equally evident in each series considered by itself. Not only so, but the total yields for 1925 and 1926, given in the same table, show the same result. This would appear to point to the fact that the differences observed are undoubtedly due to the style of plucking adopted, and that, taken over the six years for which the experiment has been carried out, it may be concluded, with justification, that, at Tocklai, plucking to six inches, and then to the janum, gives more leaf than either of the other treatments adopted, while the least successful, from the point of view of production, has been that which leaves most growth on the bush, namely, plucking to six inches to begin with, and then to a leaf for the rest of the season.

TABLE V.

The effect of the different classes of Plucking on the yield, as shown by each separate series to date.

Class of Plucking.	Yield to date (1921–1926 inclusive) in Maunds of Made Tea per acre.		
	First Series (lines 2 to 10).	Second Series (lines 11 to 19).	Third Series (lines 20 to 28).
6	55·2	54·4	54·8
4L	48·6	45·0	47·8
6L	43·7	44·1	41·5
Yield for 1925 and 1926 inclusive in Maunds of Made Tea per acre.			
6	20·4	20·0	19·9
4L	18·3	17·7	17·5
6L	17·3	17·1	16·5

In Table VI the results for the years 1925 and 1926 are tabulated in still greater detail, and from this table two deductions can be drawn.

TABLE VI.

The effect of the different classes of Plucking on the yield and on the thickness of the Pruning wood, as shown by each separate series in 1925 and 1926.

Class of Plucking.	Series.	1925 Tea. Yield in maunds per acre.	1925 Wood. Diameter in inches.	1926 Tea. Yield in maunds per acre.	1926 Wood. Diameter in inches.
6	First ...	11·4	·197	9·0	·221
	Second ..	10·9	·198	9·1	·246
	Third ...	9·9	·219	10·0	·233
4L	First ...	9·5	·223	8·8	·231
	Second ...	8·8	·209	8.9	·246
	Third ...	8·3	·236	9·2	·238
6L	First ...	9.4	·213	7·9	·238
	Second ...	9·2	·212	7·9	·242
	Third ...	7·9	·220	8·6	·247

First, it is evident that, so far as outturn goes, the results of one year's observations are not to be trusted entirely. In the case of the first and third series, the results are in agreement with those deduced from six years' observations, but in the case of the third series there is a discrepancy, the bushes plucked to six inches, and then to a leaf, having yielded more than those plucked to four inches, and then to a leaf, in 1925.

Second, it is evident that although, in the one year, increased crop appears to mean thinner wood, the results of one year, in this regard, cannot be compared with those obtained in another year. Whatever the relative yields were found to be, the wood was in all cases thicker in 1926 than in 1925, and, when one remembers that the shrinkage on drying was greater in 1926 than in 1925, the difference is emphasised. This increased thickness of wood occurred in all cases, whether the outturn was greater or less in 1925 than in 1926. This phenomenon can only be put down to the fact of 1926 being a more favourable year for the production of wood than 1925, but it is interesting to note that the average outturn per acre, for

the bushes under consideration, was 9.5 maunds in 1925 as compared with 8.8 maunds in 1926.

The effect of " Breaking Back."

The effect of Breaking Back is shown in Table VII.

TABLE VII.

The effect of Breaking Back.

Treatment.	Yield to date in Maunds of Made Tea per acre (1921 to 1926 inclusive).	Mean diameter pruning wood in inches.		
		1924	1925	1926
Broken back (BB +)	59·9	·228	·207	·237
Not broken back (BB −)	57·9	·237	·217	·239

The results show a slightly increased yield in the case of bushes on which the long shoots are broken back, as compared with the bushes on which they are left, but this increased yield is small, and, as the figures in Table VIII show, was not maintained in 1925. Here, again, thinner wood accompanies the increased yield, if the yield for six years be taken as a guide, yet this is discounted by the fact that in 1925 the reverse was the case, while in 1926 there is little or no difference in thickness of the pruning wood.

TABLE VIII.

Treatment.	Yield in Maunds of Made Tea per acre.	
	1925	1926
B B+	9·2	9·4
B B−	10·0	8·5

Table IX gives the results for 1925 and 1926 for each series of bushes.

TABLE IX.

The effect of Breaking Back.

Treatment.	Series.	1925 Tea. Yield in maunds per acre.	1925 Wood. Diameter in inches.	1926 Tea. Yield in maunds per acre.	1926 Wood. Dianneter in inches.
B B + ...	First ...	10·1	·200	9·4	·232
	Second ...	9·6	·199	9·8	·246
	Third ...	8·5	·224	9·0	·233
B B – ...	First ...	10·3	·222	7·9	·231
	Second ...	10·4	·210	8·0	·243
	Third ...	9·3	·221	9·4	·242

From this table it may be seen that in 1925 the increased return for the bushes which were not broken back was regular throughout all three series, while in 1926 the third series differed from the other two in that the bushes which were not broken back gave a higher yield than those which were broken back. A further curious observation is that, as a rule, thicker wood was obtained on the plots which gave the higher yield, the one exception again being the third series, in which, in 1925, the bushes giving the lower yield (broken back) carried the thickest wood. The one consistency shown in this table is that in all cases the pruning wood was thicker in 1926 than in 1925, whether yields were higher or lower.

Thus, it may be said that, speaking generally, the results as a whole show a small increase in crop due to breaking back, and a tendency to the production of thicker wood on the bushes which were not broken back, but that the results, when examined in detail, show such irregularity that the differences obtained can as yet hardly be regarded as significant. Certainly, in this case, thinner wood has not always accompanied increased yield.

In Table X the results are tabulated in still greater detail, to ascertain whether any of the different styles of plucking, combined with the breaking back, has caused irregularities to appear, which do not occur with other styles of plucking. This table shows conclusively that the irregularities occur, whatever the style of plucking with which breaking back is combined.

TABLE X.

The effect of Breaking Back.

				1925		1926	
Treatment.			Series.	Tea. Yield in maunds per acre.	Wood. Diameter in inches.	Tea. Yield in maunds per acre.	Wood. Diameter in inches.
	BB	BJ					
6	+	+	First	10·7	·195	9·6	·216
			Second	10·2	·191	10·5	·248
			Third	8·5	·218	9·8	·225
6	–	+	First	12·1	·199	8·0	·220
			Second	11·7	·195	8·2	·247
			Third	11·3	·225	10·9	·234
4L	+	+	First	9·8	·199	10·4	·229
			Second	8·5	·212	10·5	·250
			Third	8·2	·238	8·5	·248
4L	–	+	First	9·1	·243	8·6	·220
			Second	8·5	·217	8·8	·237
			Third	9·2	·225	9·5	·231
6L	+	+	First	9·8	·205	8·3	·250
			Second	8·3	·193	8·3	·240
			Third	8·8	·216	8·8	·225
6L	–	+	First	9·7	·224	7·0	·254
			Second	10·9	·218	7·0	·244
			Third	7·5	·212	7·8	·260

It is therefore obvious, that, so far as breaking back is concerned, the experiment has not yet been carried far enough to draw definite conclusions, although the results to date, taken as a whole, indicate that there is a tendency, with breaking

back, to a very small increase in yield, accompanied by a tendency to the formation of thinner pruning wood.

The benefit which has occurred from breaking back is, so far, doubtful, beyond the fact of its keeping the plucking surface down, thereby making the bush easier to pluck and the plucking easier to supervise.

The Effect of Plucking Banjhies.

Table XI shows the effect of plucking Banjhies.

TABLE XI.

The effect of Plucking Banjhies.

Treatment.	Yield to date in Maunds of Made Tea per acre. (1921 to 1926 inclusive.)	Mean diameter of pruning wood in inches.		
		1924	1925	1926
Banjhies plucked (BJ +)	59·9	·228	·207	.237
Banjhies left (BJ –)	51·4	·239	·217	·244

It will be seen that, as before, there is still an increased yield from the bushes on which banjhies were plucked, as against those on which banjhies were left, and that this difference in yield is considerable, being 8.5 maunds per acre in six years. This increase, as will be seen from table XII, is continuing, for, while in 1925 the yields from the two treatments were the same, in 1926 the bushes from which banjhies were plucked gave 4/5 maund of pucca tea per acre more than those on which banjhies were left.

TABLE XII.

The effect of Plucking Bhanjhies.

Treatment.	Yield in Maunds of Made Tea per acre.		
	·1925	1926	Total 1925–26.
BJ +	9·2	9·4	18·6
BJ –	9·2	8·6	17·8

As before, also, the bushes on which banjhies were left produced the thicker pruning wood, though it will be observed that this also occurred in 1925, when the yields from the two sets of bushes were equal.

Table XIII gives the results in detail.

TABLE XIII.

The effect of Plucking Banjhies.

Treatment.	Series.	1925 Tea. Yield in Maunds per acre.	1925 Wood. Diameter in inches.	1926 Tea- Yield in Maunds per acre.	1926 Wood- Diameter in inches.
BJ +	First	10·1	·200	9·4	·232
	Second	9·0	·199	9·8	·246
	Third	8·5	·224	9·0	·233
BJ –	First	9·9	·212	8·4	·243
	Second	9·6	·211	8·1	·245
	Third	8·3	·230	9·3	·244

Irregularities are again observable, occurring in the second series, the irregularity being in crop in 1925, and in thickness of wood in 1926, and in the third series, in which the bushes on which banjhies were left gave the bigger outturn in 1926. The wood is not consistently thicker where the crop taken has been less, nor where banjhies have been left, though this has generally been the case. It was consistently thicker in 1926 than in 1925.

Summary.

It is noticeable that the observations made in 1925 and 1926 confirm most of the indications deduced in the previous note on the result of these experiments.

Allowing the bushes to continue to make growth after plucking has commenced has resulted in a decrease of crop.

This has occurred whether the continued growth has been the result of the class of plucking adopted, or of leaving banjy shoots on the bush.

The effect of breaking back on the yield continues to be irregular, and the benefit of this procedure, from the point of view of outturn, to become more doubtful.

When the results are considered as a whole, it seems to be indicated that, as a general rule, thicker pruning wood accompanies a lower yield, but that this is not necessarily so.

The detailed observations indicate that, though there is a tendency for the effect of a treatment, where that is marked, to proceed in the same direction over a series of years, it may, in any given year, be entirely reversed for some reason probably entirely outside the scope of the experiment. Results based on one year's observations are therefore of no value.

The results show, beyond question, that whatever the treatment the plots received, they made better wood in 1926 than in 1925, and this occurred whether they yielded more or less leaf in one year than in the other.

Observations regarding thickness of wood are therefore only comparable if made in the same year, and the season exercises a profound influence on the thickness of the wood obtained.

The experiments are being continued.

SOIL BACTERIA IN RELATION TO CULTIVATION AND MANURING.

BY

S. F. BENTON.

The object of this article is to point out the importance of bacteria as a definite factor in the cultivation and manuring of the tea bush.

The soil is usually considered as a mixture of particles of various sizes which are classified as coarse sand, fine sand, silt, fine silt, and clay, together with small amounts of organic matter and salts necessary for the growth of plants. This type of analysis gives the idea that the soil is a dead substance acting merely as a support and a reservoir of food for the roots of plants.

A brief examination of the facts shows that this view is incorrect. It is well known that plants can only take up from the soil substances in solution. Being soluble in water, these substances can all be washed out by rain, though in some cases this leaching takes place very slowly. In any case it is obvious that unless some factor is constantly at work converting complex insoluble substances into simple soluble salts, all plants would sooner or later die of starvation.

A normal top soil contains bacteria and fungi in very large numbers, and these are quite indispensable for agriculture. Not only are they engaged in breaking down manures and dead matter, and in producing soluble phosphates from the soil particles, but certain groups take nitrogen from the air and leave it in the soil in a combined form, thus helping to preserve the fertility of the soil.

Types of micro-organisms in the soil.

Three large groups of micro-organisms are found in the soil. These are called Fungi, Actinomycetes and Bacteria. The fungi are mainly concerned with the destruction of wood, and their efficiency in this respect may be judged by the

rate at which tea prunings disappear after hoeing in. These fungi must not be confused with those which produce diseases of the tea bush. The latter attack living tissues, frequently causing the death of the bush. The true soil fungi only attack matter which is already dead, and are unable to grow on living tissues except in rare cases.

With the actinomycetes or "ray fungi" we are not particularly concerned in this article. They are chiefly of interest because they are responsible for the "earthy" smell of soil, which is most marked after rain.

The bacteria carry out a much wider range of changes. Certain of them break down complex manures and the remains of dead plants and animals, converting the nitrogen to ammonia; others convert this ammonia to nitrate. Others take the nitrate out of the soil while engaged in breaking down green manures and jungle which has been hoed in. Another group changes the soil nitrates and ammonia to free nitrogen which goes into the air and is lost;—the activities of these bacteria must be controlled. Nitrogen fixing bacteria fix nitrogen from the air,—one of the most valuable processes known. Sulphur bacteria convert sulphur to sulphuric acid—hence the treatment sometimes advised, of adding sulphur to a soil to increase its acidity.

In short there are few processes connected with agricultural practice in which bacteria do not play an important part.

The causes of soil deterioration.

The conditions in a normal jungle soil, before cultivation is commenced, are as follows. Bacteria in the soil produce nitrates, which are taken up almost completely by the heavy growth of plants and trees. From the trees, dead leaves and branches fall on the soil, adding large quantities of organic matter and nitrogen.

The organic matter is attacked by fungi and bacteria, the major portion being decomposed and given off into the air as carbon dioxide, which is again taken up by the green jungle. The nitrogen in the remainder is converted to nitrate by bac-

teria, and in this form once more enters the plant through the roots. The presence of organic matter in large quantities stimulates nitrogen fixation, and the soil steadily becomes richer, jungle growth increasing in proportion.

The increasing growth of jungle roots, however, has the effect of restricting bacterial activities, so that the amount of available nitrogen becomes progressively less. Eventually a point is reached at which the mineral food supplied, through the agency of the bacteria, is just sufficient to support the existing jungle, which in turn supplies little more organic matter than is necessary for the bacteria themselves.

Equilibrium having been established in this manner, there is the minimum of wastage, and soils in this state will remain for long periods without radical change in their composition, unless the cycle is upset, *e.g.*, by fire or floods.

The jungle is now cut down to form a tea garden. The trees and branches are removed and the smaller plants are buried or burnt. The soil is thus deprived of its normal source of organic matter. The land is hoed to destroy shallow rooted jungle and, the bacteria being now free to act without hindrance, decomposition sets in at a tremendous rate. Nitrates are formed much more rapidly than they can be absorbed by the tea and are washed out by rain. According to Mann, new tea gardens on very rich soil may give poor quality for some years, on account of the excessively coarse growth brought on by the accumulation of nitrates.

The amount of nitrogen lost in this way may reach alarming proportions as may be seen from the following figures (Mann.) :—

Period under tea.	Weight of nitrogen in virgin soil. lbs. per acre.	Loss of nitrogen in lbs. per acre.	Annual loss of nitrogen in lbs. per acre.
(1) 10 years ...	7,000	1,500	150
(2) 35-40 years ...	10,000	5,500	157
(3) 28 years ...	7,000	1,500	57·7
(4) 20 years ...	13,000	3,000	150

The amount of nitrogen removed in an eight-maund crop is about 30 lbs. per annum and a little more is used in building the frame of the bush, so that a total loss of up to 130 lbs. per acre per annum may occur. During the early life of the garden this annual loss is probably very much higher, since the most readily available nitrogen is attacked first.

Much of the nitrogen in a soil is very resistant to bacterial attack, so that a soil which still contains 3,000 lbs. of nitrogen per acre may grow very poor tea, while the addition of only 40 lbs. per acre of a soluble form of nitrogen, *e.g.*, sulphate of ammonia or sodium nitrate, may bring about a 50 per cent. increase of crop.

In soil No. 2 above, for instance, the loss of 5,500 lbs. out of 10,000 lbs. per acre may represent almost complete exhaustion of the available nitrogen in the soil.

Cultivation also brings about a marked increase in the rate of decomposition of the soil's organic matter, and in a comparatively few years a rich soil may deteriorate considerably.

To preserve the fertility of the soil, the nitrogen and organic matter content must be maintained and this is best effected by making use of the soil bacteria.

The loss might be made good by the extensive use of artificial fertilisers alone, but the cost would be prohibitive. To take an example let us assume that the soil is losing annually 100-120 lbs. of nitrogen per acre. To replace this with ammonium sulphate would require 5 cwt. per acre which, at the price of Rs. 180 per ton, would cost Rs. 45 per acre, plus freight.

This, however, would do nothing towards maintaining the content of organic matter, apart from stimulating the growth of jungle and bush. If oilcake were used to supply both nitrogen and organic matter the quantity required would be 28 maunds per acre at a cost of Rs. 105. Any attempt to preserve soil fertility by the sole use of artificial manures is thus economically unsound.

As mentioned above, there exist in the soil bacteria capable of taking nitrogen from the air and making it available for plants. An important group of these consists of the well known legume bacteria, which are found in the nodules on the roots of green crops such as Boga medeloa, cowpeas, dhaincha, and the like. Others live a free life in the soil and obtain their food from fresh organic matter, fixing nitrogen in return.

The most successful agricultural practice thus resolves itself into making the greatest possible use of these bacteria, and it is hoped that this article will show how these, and other valuable organisms, may best be encouraged.

The Nature and Habits of bacteria.

The importance of bacteria in the soil having been established, their nature and mode of life will be considered, together with the application of this knowledge to agricultural practice.

Although commonly referred to as "bugs," bacteria are in reality not animals but plants of a low order, being even lower down in the scale of life than the fungi. Like the fungi, they are devoid of the green colouring matter of plants and therefore they cannot use the energy of the sun's rays directly.

In point of fact, direct sunshine is nearly always fatal to bacteria, which probably accounts for the lower numbers of these organisms in the top inch or two of soil (see below).

Their inability to use the energy of the sun direct determines their mode of nutrition. They must obtain their energy second-hand, by breaking down substances with a high energy content, *i.e.*, residues of plants and animals.

For this reason the majority of bacteria fall naturally into two groups, according as they live on living or dead matter. The first group contains the bacteria which cause diseases of living animals and plants, and the second group those which reduce the dead material to simple bodies which can once more be absorbed by plants. It is the failure to distinguish between

these two groups which has given rise to the idea that all bacteria are harmful and should be suppressed where possible. Actually, were all bacteria and fungi destroyed, life on the earth would become extinct.

The soil bacteria belong almost entirely to the second group, with the exception of a few species which live on mineral salts only.

Form of bacteria.

Bacteria occur in a variety of shapes, the most common being rods of varying length, and small spheres. In addition there are "comma" and spiral shapes. They are usually found in "colonies" which may consist of a few hundred or many million bacteria. A colony of five million typical bacteria would occupy the space of a pin's head. In the soil, these colonies are usually found surrounding small particles of lime.

Although they are plants by nature, bacteria are able to move about in the soil water. By special staining methods they are seen to have long waving "arms" or flagella, and these are lashed violently backwards and forwards in the liquid, causing the organism to move at a considerable speed in relation to its size. These flagella are of special interest in connection with the bacteria of green crops.

Growth and reproduction.

In bacteria the simplest and most efficient form of reproduction is met. When a cell has grown to its full size it divides in two, and each of the resulting cells is exactly the same as the parent. Sexual reproduction is absent and in consequence, cross-breeding being impossible, bacteria tend to maintain their characteristics. For example, there is little difference between the nitrifying organism of Assam and that of England.

Certain bacteria also form spores which are very resistant to heat and may be boiled in water without loss of vitality.

Under favourable conditions a single cell can form two cells in half an hour. At this rate, after two days the descendants of a single cell would number 281,500,000,000. Under ordin-

ary conditions, lack of food soon slows down this rate of increase, though if food is available in large quantities the effects of bacterial growth may be marked.

This is brought out by the temporary depression of crop noticed when a green manure or paddy straw is hoed in. Enormous quantities of cellulose are put into the soil, and the cellulose bacteria increase rapidly. In so doing they remove almost the whole of the nitrates from the soil, and until the nitrogen in the green material starts to decompose, the tea suffers from nitrogen starvation. The same fact has been brought out in a laboratory experiment with oilcake. When this manure was added to soil at the rate of 8 tons per acre there was an immediate loss of 90 lbs. nitrate per acre, probably the whole of which went to feed the cellulose bacteria. All the nitrogen removed is returned to the soil when the bacteria die off, after their work is done.

Bacteria in the Soil.

In the soil, the bacteria occur in incredible numbers, a normal fertile soil containing about 100,000,000 to the ounce, or approximately five thousand million million per acre. These great numbers are somewhat discounted by size—the average bacterium measuring about one twenty-thousandth of an inch in length—but they are nevertheless sufficient to make all the difference between a naturally fertile soil and one on which tea culture is only possible by constant resort to artificial fertilisers.

Distribution of bacteria in soil.

The numbers vary greatly with depth. The following table shows the distribution in the top two feet of soil:—

Depth.	Number of bacteria per ounce of soil.
2 inches	24,500,000
4 ,,	40,800,000
6 ,,	40,800,000
12 ,,	1,820,000
18 ,,	525,000
24 ,,	100,000

Here is the explanation of the well known infertility of the subsoil. The reasons for the failure of bacteria to survive in any but the top few inches are several. Lack of air in the subsoil is one of the main factors; another is the almost complete lack of available organic matter. In addition, the soil itself behaves as a very efficient filter in preventing the bacteria from being washed down by rain, acting in the same way as the earthenware candle in the filter which is to be found in every bungalow.

These figures act as a strong condemnation of the practice of digging drains and piling the excavated earth upon the tea on either side. If new drains are to be opened in an area already under tea, the subsoil should be spread thinly over the soil for some distance on either side. Whenever it becomes necessary to deal with subsoil in large quantities it should be freely mixed with cattle manure, which will have the effect of increasing the content of organic matter while supplying a very large number of bacteria.

The same applies when it is necessary for any reason to plant up land from which part of the top soil has been removed *e.g.*, by wash.

This infertility of the subsoil is one of the main arguments in favour of terracing on steep slopes in an exposed position. The top soil with its attendant bacteria and organic matter is easily lost and may take years to replace. On gardens where the top soil has already been lost, the continued use of artificial fertilisers such as sodium nitrate and ammonium sulphate is merely putting off the day of reckoning, and the health of the bushes will be maintained only while these manures are present. The counsel of perfection would be to build up a new top soil by heavy dressings of cattle manure, green crops, and decay-jungle.

The Conditions necessary for Bacterial Life.

Air.

There are two groups of bacteria in the soil, one of which requires abundance of air for its life processes while the other can live in entire absence of oxygen. The members of the first group carry on most of the

valuable processes in the soil, while those of the second group are on the whole undesirable. One species of the latter has the power of destroying nitrates and giving off free nitrogen causing a very serious loss to the soil. When the oxygen supply is insufficient these and other bacteria actually produce plant poisons so that their harmful effect on plants is twofold. It is thus necessary to restrict their activities as far as possible,

(a) by keeping the soil in good tilth and so allowing air to penetrate freely to the greatest possible depth.

(b) by preventing waterlogging of the soil by an adequate drainage system.

Moisture.

Bacterial activity is dependent on a sufficient supply of moisture in the soil. For the best working, the moisture content must lie between certain limits. Thus at Tocklai the optimum moisture content for the nitrifying bacteria is near 14 per cent. (*i.e.*, 35 per cent. of saturation). When the moisture content falls to 10 per cent. (25 per cent. of saturation) in the cold weather, bacterial action is checked, and the bush is left without its normal food supply. Similarly when the moisture content rises to near the saturation point, the activities of bacteria are greatly restricted, and unless steps are taken to remove the excess water by drainage, a race of harmful bacteria may take possession of the soil. The disappearance of excess moisture from a well drained soil is brought out by the following figures :—

Date.	Rainfall.	Percentage of moisture in soil.
May 27th	0·24″	18·41
„ 28th	nil	17·27
„ 29th	0·05″	......
„ 30th	nil	16·30
„ 31st	nil	14·40
June 1st ...	nil	13·89
„ 2nd	1·72″	18·38

Thus under dry conditions the moisture content of the soil falls fairly rapidly until it reaches the optimum. From other figures it is found that below this point the soil holds on to its moisture with greater tenacity.

The actual degree of saturation most favourable to bacteria appears to vary in different soils, usually lying between 40 per cent. and 60 per cent. The following figures illustrate this point.

Degree of saturation.	Production of nitrates from peptone by bacteria (milligrams per 100 gms. of soil).		
	Tocklai.	Amluckie.	Red Bank.
35%	7·36	......	......
40%	6·05	7·14	8·52
45%	4·90	8·24	9·89
50%	4·39	8·79	16·48
55%	3·57	10·44	13·20
60%	......	12·36	7·70

To preserve the maximum fertility, the soil moisture must therefore be kept as near as possible to the optimum :—

(1) by adequate draining to remove excess water during the rains.

(2) by the use of the cold weather mulch to maintain the moisture content at the highest possible level during the cold weather.

Prolonged droughts such as occur fairly frequently in the tea districts of the Terai and South Sylhet may cause a serious destruction of soil bacteria, leading to a slow recovery of the bush. When possible it is as well to apply a dressing of cattle manure on weak sections after a severe drought, as this will have the double effect of supplying food for the bush while adding a large number of active bacteria to the soil. If the drought has not been too severe, the effect of the first rain is most marked. The nitrate content of the soil, which has remained at a very low level throughout the cold weather, suddenly jumps up to nine or ten parts per million. This sudden increase doubtless plays a considerable part in bringing on the first flush.

Food.

The food requirements of the majority of soil bacteria may be placed under two headings, *viz.* :—

Organic matter. Lime.

Lime does not act so much as a true food, but rather as a neutraliser of the acids produced by the bacteria in their normal life. This will be discussed below.

Organic matter is used by bacteria in enormous quantities. For example, American workers have found that the nitrogen fixing bacteria when supplied with straw as their food fix 7¼ lbs. of nitrogen from the air while decomposing a ton of straw. When the green matter from clover was supplied instead of straw, the amount of nitrogen fixed was about 27.5 lbs. per ton of material decomposed. It is probable that the results with the green manures in use in the tea districts would be comparable with the latter figures, but work on this point has not yet been carried out.

From these figures it appears that the amount of nitrogen fixed by the soil after a green crop has been hoed in would be in the neighbourhood of 80 lbs. per acre, apart from the 20 lbs. fixed by the crop itself. It must be pointed out that these figures were obtained as a result of laboratory experiments and in the field different results might be obtained. From a good crop a gain of at least 100 lbs. nitrogen per acre is to be expected, which compares very favourably with the usual dressing of 30 lbs. given as ammonium sulphate.

The organic matter requirements of bacteria are seen to be very large. Under jungle conditions, these requirements are supplied by the annual leaf fall from trees and by the succession of low-growing grasses. On the tea garden, however, jungle must be suppressed for it competes with the bush for food. The depression caused by jungle is well brought out by the following figures obtained from the Borbhetta cultivation plots.

Plot No.	Treatment.	Relative efficiency of nitrifying bacteria.	Crop 1926.
87	Monthly cheel	201·0	10·60
93	6 light hoes	176·7	10·16
88	1 light hoe. Extra manure	141·3	6·16
95	Sickled only	100·0	3·68

Plot 87 is kept free from jungle. 93 is nearly free while on 88 and 95 jungle is plentiful. It is interesting

to note that the presence of jungle has had harmful effects on the soil bacteria as well as on the tea. This is possibly due to toxins given off by the jungle roots.

On the contrary, the practice of growing shade trees is very beneficial. The roots of the trees are too far below the surface to have much effect on the bacteria in the top few inches of soil. The wide-spread root system does much to minimise the loss of nitrates and soluble salts which would otherwise take place through leaching, and finally the tree itself deposits annually a large amount of organic matter, containing some 3 per cent. of nitrogen.

From the figures given above it is clear that the suppression of jungle is one of the most important factors in tea garden management. Undoubtedly the best method of effecting this is to grow tea bushes that touch each other so that jungle has no chance to grow—while the organic matter content of the soil is partially maintained by leaf fall and prunings. This is a counsel of perfection not easy to follow on gardens with a large percentage of deteriorated tea and vacancies, but approximated to on very large areas of good tea.

Jungle is usually eliminated by the use of the light hoe. Unfortunately the light hoe is very wasteful of the soil reserves for it is followed by a sudden increase in nitrates amounting to some 20 lbs. per acre (on Tocklai soil). A heavy fall of rain following cultivation will remove almost the whole of this and the soil will be poorer in proportion. The destruction of organic matter is stimulated in a similar manner.

This loss after light hoeing is avoided to a considerable extent by substituting "cheeling" or cultivation with a spring-tine harrow and buffalo, both of which effectively suppress jungle while disturbing the soil to a depth of a few inches only. The possibility of using either of these forms of cultivation depends largely on circumstances, labour being concerned in the former case, and the drainage scheme, transport facilities, and distribution of shade trees in the latter.

The fact remains that cultivation causes considerable losses of nitrogen. These can be made good in two ways, *viz.*—by addition of manures and by nitrogen fixation. Nitrogen fixation is, however, dependent on the amount of available organic matter. It is therefore clear that above all things the organic matter content of the soil must be kept up, if the bacterial population is to be kept in good working order. This fact is so important that a manuring scheme taking no consideration of the soil bacteria may be considered incomplete.

The tendency of late years has been to rely more and more on the purely artificial fertilisers such as Sulphate of ammonia and Calcium cyanamide for the nitrogen supply, chiefly on account of their low cost. It is important to remember that these manures are added solely with the idea of increasing the crop, and that they have little or no direct beneficial effect on the soil bacteria. A programme incorporating these manures must always include regular green cropping or dressings of cattle manure, preferably well-rotted with paddy straw.

Lime.

For the majority of bacterial processes a neutral or slightly alkaline soil is required. Tea requires an acid soil and anything approaching neutrality appears to be definitely harmful. On the other hand, the fertility of the soil depends largely on the activities of the bacteria, to which lime is an essential. The difficulty is met by a compromise, lime being added in quantities insufficient to change the reaction of the soil, but under conditions where it will have most effect on the bacteria. To take an example, let us consider a typical tea soil with a "Hopkins acidity" of 400. This means that 400 lbs. of lime would be required to bring 1,000,000 lbs. of soil to a condition of neutrality. Taking the weight of an acre of soil to a depth of nine inches as 3,000,000 lbs., we find that this soil would require 1,200 lbs. lime per acre to make it neutral.

Now five maunds of crushed limestone contains about 200 lbs. of free lime, so that this amount could be supplied per acre without making any appreciable difference to the acidity of

the soil, although being of great value to the bacteria. The best time to add lime is before sowing a green crop, so benefiting the green crop itself and also the bacteria on whose presence and activity the efficiency of the crop depends. The lime should be distributed only in the rows where it is intended to sow the green crop, and preferably in the seed-bed itself.

Experiments conducted at Bŏrbhetta showed that on this particular soil, Rahar would nŏt grow at all without lime. When this deficiency was made good the crop obtained increased with increasing amounts of lime, until a dressing of 80 maunds of crushed limestone produced a Rahar crop of 250 maunds per acre.

The Tocklai lime policy thus becomes comprehensible when considered in terms of bacteriology. Continual applications of lime over a period of years, or the application of a large dressing is seldom, if ever, advised, but small dressings are recommended from time to time to satisfy bacterial requirements.

The conditions for optimum bacterial working may now be summarised :—

Aeration of the soil.
Ample moisture, but avoidance of excess by draining.
Plentiful supply of foodstuff in the form or organic matter.
Suppression of jungle.
Small amount of lime at intervals on the more acid soils.

Green Manuring.

The space available will not allow of a description of all the bacterial processes taking place in the soil. As the practice of green manuring is of great importance in tea soils, the relation of bacteria to green manures will be dealt with more fully here, and a discussion of other bacterial processes will be left till later.

It is generally realised that bacteria are intimately connected with green manures. On the roots of all members of the legume family may be found small nodules. These vary in numbers with different species of plants, and with different conditions of growth.

If one of these nodules be cut in two, it is found to consist of an outer white layer of firm consistency, surrounding an inner mass, often pink in colour, which is soft and slimy. This inner mass is seen under the microscope to consist of enormous numbers of slender bacteria, entirely filling the cells of the nodule. It is to these bacteria that the legumes owe their value as green manures, for, as stated above, they have the power of taking nitrogen from air, building it into complex soluble substances, and passing these on to the plant. In return for these substances, the plant supplies the bacteria with sugars, water and salts—substances which enable the bacteria to carry out their work of nitrogen fixation.

There is here a perfect example of division of labour.

The necessity of bacteria for economical growth of green crops.

The ordinary green plant takes up its nitrogen as nitrate or ammonia. On this account jungle competes with the tea bush for food, and as it has its roots mainly in the top few inches of soil, where bacterial action is at its highest, the jungle has first call on the food supply. Hence, apart from reasons of convenience, jungle must be suppressed.

A green crop without nodules acts in the same way as jungle, the rate of growth and final crop being determined by the amount of nitrate and ammonia in the soil. Consequently any growth of a green crop without root nodules is at the expense of the tea.

If nodules are present on the roots, the position is altered. The bacteria in the nodules draw relatively large quantities of nitrogen from the air, and with the aid of this nitrogen the plant grows far larger than it would were it living on soil nitrates alone. For successful green crops the requirements of the bacteria must be studied and met.

The bacteria are mainly present in the soil in an inactive state. They possess no power of moving through the soil and little power of infecting roots of legumes. When a soluble phosphate is supplied the bacteria develop flagella, become highly

active and are able to infect the plants readily. The use of phosphate is therefore a wise policy wherever green crops are to be sown, and many cases of failure may be put down to the neglect of this precaution. The best phosphates to use are Basic slag, Superphosphate, Belgian flour phosphate and Algerian phosphate. The quantities usually recommended are as follows :—

Superphosphate	...	... 2 mds. per acre.
Basic slag ...	...	... 2 ,, ,,
Belgian phosphate	...	... 3 ,, ,,
Algerian phosphate	...	... 2 ,, ,,

Inoculation of green manures.

From the above remarks it is clear that the value of a green manure depends on the extent of infection by bacteria. The question now arises, whether the legume bacteria in the soil are present in sufficient numbers to secure the maximum infection. In some districts it is found almost impossible to grow a good green crop and the idea suggests itself that lack of bacteria may be the cause. If this is so, artificial inoculation of the soil or the seed might be resorted to with success. So far, little work has been done along these lines in the tea soils. A few isolated trials were made in the Tocklai district this year with varying results. The bacteria were grown on an agar (china-grass) jelly, and just before planting, the seed was moistened with a suspension of these bacteria in water.

Cowpeas gave poor results. Not only was it found difficult to grow the bacteria, but the inoculated plants were barely as good as the uninoculated. Boga medeloa was unsatisfactory owing to unfavourable climatic conditions and practically the whole crop failed. With dhaincha more promising results were obtained. The results of the experiments were :—

Yield from 11 rows uninoculated.	Yield from 11 rows inoculated.
590 lbs.	918 lbs.

Increase from inoculation 328 lbs = 55.6 per cent.

The seed was planted in alternate rows, alternate rows of seed being inoculated. Phosphate was not supplied and the soil in the section was poor. In almost every case, an inoculated row gave a greater weight of green material than the uninoculated rows on either side.

Definite conclusions cannot of course be drawn from a single experiment of this nature. This Department will be pleased to get into touch with any planter who has continual difficulty in establishing a green crop and who would like to carry out experiments in inoculation.

* * *

The science of agriculture has passed through three main stages in the course of its development. In ancient times the Mechanical stage held the field. Improvements were chiefly along the lines of cultivation and drainage, although a considerable amount was known about fallowing and the use of green manures such as clover in a crop rotation. At the beginning of the nineteenth century agriculture passed definitely into the Chemical stage and tremendous advances were made in the science of manuring; during the closing years of the same century the Biological era arose and gained favour in so rapid and sensational a fashion that there was a tendency in certain circles to regard bacteria as the beginning and end of agriculture.

Actually there are no hard distinctions to be drawn. The mechanical, chemical, and biological phases are all intimately connected and interdependent, and a change which affects one will affect all.

In this article the claims of the bacteria have been put forward. Their importance in soil fertility has been brought out and the conditions they prefer have been enumerated. No attempt has been made to deal at length with individual bacterial processes in the soil, but the importance of organic matter has been emphasised, since this substance is the chief food, directly or indirectly, of the majority of soil bacteria; and on these, eventually, the economic cultivation of the tea bush depends.

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THE CULTIVATION EXPERIMENT PLOTS AT BORBHETTA.

BY

P. H. CARPENTER AND H. R. COOPER.

The cultivation experiment plots at Borbhetta occupy nineteen long narrow parallel strips of tea each 1/3 of an acre in area. Four different lots of tea are included and there is a " check plot " for each lot, so that no experimental plot is far removed from its check plot. Each different type of cultivation is applied only to a single plot so that there is no direct method of determining the degree of accuracy of the experiments.

The tea was planted in 1916 and 1917 and all treated alike up to the end of 1921. The yields for 1921 however do not in all cases give any indication of the relative initial yielding capacities of the plots because the number of infillings, still yielding nothing or little, was great in some plots and they were not evenly distributed.

In considering results it will be assumed that, had all the plots been treated similarly, they would have been giving similar yields in 1926. Differences in yields actually given in 1926 are ascribed to the effects of the different treatments.

The assumption is admittedly an important and far reaching one; but our experience with many other sets of similar plots justifies it within fair limits.

Such long narrow plots of tea, when mature, if not far removed from each other, do give roughly equal yields if under identical treatment. The difference between such similar neighbouring plots is rarely more than five per cent., although in a few cases it exceeds 10 per cent. Such great differences however only occur in the case of plots which contain considerable areas of " bad patches," the presence of which is easily apparent to the eye.

It may be therefore fairly assumed that any difference exceeding 10 per cent. is due to difference in treatment, while the results are generally more accurate than that.

The effect of " bad patches " is eliminated by dividing each big plot into five sub-plots. If any plot contains a bad patch of any extent, the yield of the sub-plot containing it will be greatly less than the mean yield of the whole big plot. The abnormal sub-plot then may be neglected in considering the average yield due to the particular treatment.

Corroborative evidence also may be gathered from consideration of the relative annual rise or fall in crop from any two plots, though this evidence must be used with care since the alternation of leaving unpruned and cutting on two year wood gave such great differences in crop for successive years. In the earlier years also the plots giving very small yield in 1921 on account of large numbers of infillings, all tended to even up in crop as the infillings became mature.

In all cases the " check plot " received what is considered to be the average " good cultivation " as usually practised, that is a deep hoe, and six light hoes.

PLOTS 91 to 96, 1916-PLANTED MATELLI PLOTS.

These plots were all very fairly even when the experiments started and in their case the error of the experiment is very small. They are therefore the easiest to discuss.

Table I shows the yields in 1926 of the individual sub-plots of plot Nos. 91 to 96 and their various treatments.

Table II shows the yields from the same whole big plots during each year from 1921 to 1926.

The tea was planted in 1916 and all was treated alike till 1922. Plot 96 was originally the best plot, because one of its nine lines borders a road with no drain near the tea. This line benefits very greatly from the absence of interfering roots from tea bushes on one side. In the case of all the other plots of this series, the outside lines have wide drains

within about 2 ft. of the collars of the bushes, which in consequence give less crop than the inside bushes. Apart from this " outside-line effect " which affects one of the plots and persists throughout the experiment, all the tea of these six plots was very fairly even when the experiment started.

In these cases the 1926 yields may be taken as very fair measurements of the effects of the differences in cultivation applied, and may be allowed to speak for themselves, but may be usefully checked by reference to Table II. Each plot will now be discussed separately.

PLOT No. 91 (6 rounds forking). This in 1921 was giving practically the same yield as the check plot. When, in 1922, forking around the bushes was substituted for hoeing, the yield at once dropped significantly and continuously, till in 1925 the yield obtained was only 59 per cent. of that obtained by an equal number of light hoes.

The forking applied was such that all weeds were pulled out by the roots at each round.

Six rounds of such forking maintained a circle of always absolutely clean soil around the bushes leaving narrow strips of jungle between the bushes. On the check plot with six light hoes jungle becomes fairly thick, though not high, over the whole area, by the time the next round is due after 40 days' interval.

The difference in yield (5.4 maunds from forking against 9.1 maunds from hoeing in 1925) is consistent with the idea that there is some special virtue in keeping clean the soil between the bushes, as compared with the soil immediately around the collars. This idea is confirmed on other plots, where, as a result of cultivation only with buffalos, the tea is kept quite clean between the rows, while bad jungle grows around and through the bushes; yet the loss in crop is small compared to similar ordinarily hoed plots.

By the end of 1925, when the results from plot 92 also were considered, it appeared sufficiently well established that

six forkings gave about the same crop as two forkings. From the beginning of 1926 therefore plot 91 received the normal cultivation including six light hoes. The improvement by the end of the year is marked, and it is hoped will in time bring the crop from plot 91 up to that of the check plot, when plot 91 will be used for other experiments.

PLOT 92 (2 rounds forking).—Receives the same cultivation as plot 91 except that only two rounds of forking are given instead of six. Before the experiment started plot 92 was significantly better than the check plot and the loss in crop under this form of cultivation was large and progressive, but by 1925 seems to have settled down to an approach to a constant proportion of the check plot's yield, at which time there was little difference between the effects of two rounds of forking and six rounds of forking (plot 91).

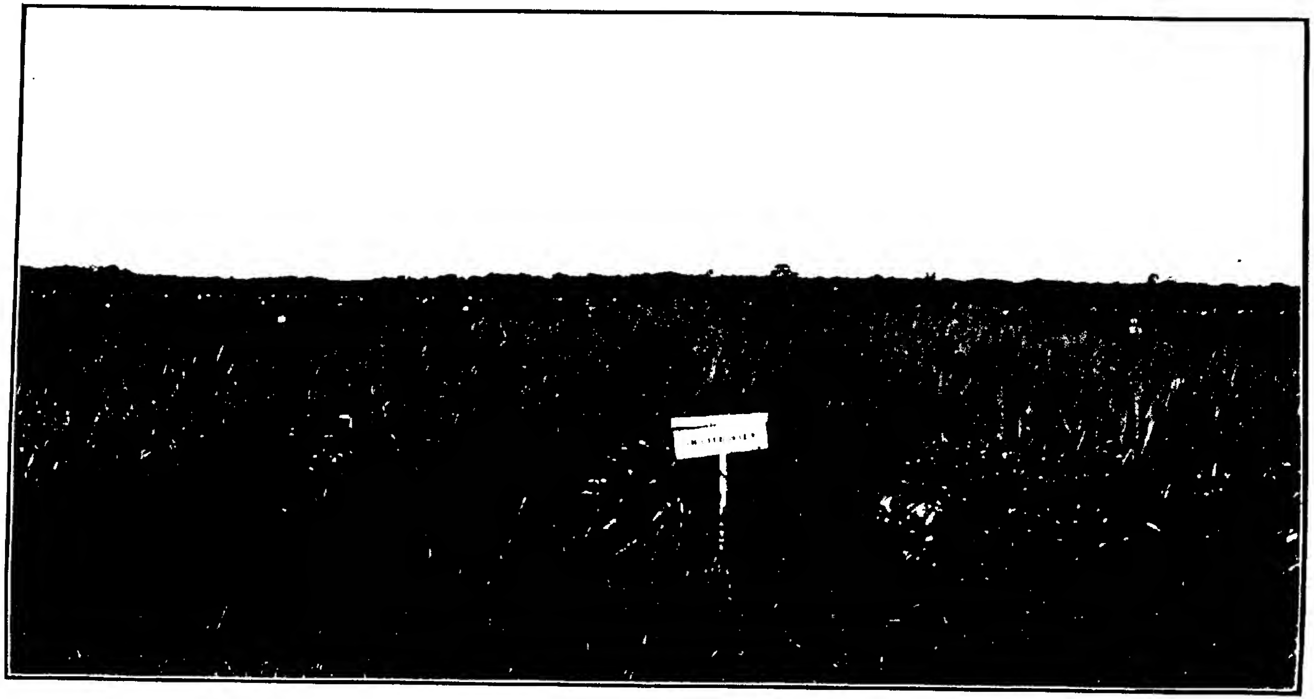
By 1925 the cover from the bush was assisting greatly in suppressing jungle under it, and two forkings kept circles around the bushes just about as clean as six rounds of forking.

Jungle growing through the bushes is a nuisance interfering with plucking. It is therefore worth while to keep it out of the bushes, but there is little gain from increasing the amount of cultivation in the neighbourhood of the collar beyond that point.

PLOT NO. 93 (one ordinary deep hoe and six light hoes—CHECK PLOT)—gets average normal cultivation (one deep and six light hoes) and is used merely for purposes of comparison with the other forms of cultivation. It represents average good tea giving fair cover but allowing considerable jungle growth unless this is suppressed by some form of cultivation.

PLOT NO. 94 (18 inches deep hoe, six light hoes)—gets the same cultivation at the same times as plot 93 except that instead of the ordinary deep hoe to 7 or 8 inches deep, it gets a hoe every year to 18 inches deep.

This is put in with extreme care. Roots are damaged as little as possible, and the work is performed in such a way that



PLOT 95.

the good top soil remains on top and is not buried. A very little subsoil has unavoidably been brought up every year so that the depth of dark top soil is now about eighteen inches.

With all this care, this excessively expensive work shows no sign of effecting any improvement in the tea.

From Table II it will be seen that up to the end of 1923 there was an apparent improvement amounting only to 3 per cent. which is not significant. Since 1923 there has been a continuous very small falling off in yield compared to the check plot. This decrease in yield is not yet great enough to be considered significant. It is however abundantly clear that this expensive operation is, at best, doing no good. There is no bad patch in Plot 94 which might reduce its yield abnormally, the yields from the sub-plots of plot 94 being in very fair agreement, as will be seen from Table I.

Plot 95 (Sickled twice). This plot is left quite clean after the cold weather cultivation, reduced tasks being given for the deep hoe in order to get all jungle buried. After this deep hoe the neighbourhood of the collar is completely cleaned by hand forking.

Its obvious suffering is therefore due only to the almost complete neglect of cultivation during the rains. It is sickled twice during the season in order that the pluckers may be enabled to pluck it; and receives no other attention. The sickling given is always quite complete, all jungle being cut to the ground right up to the collars of the bushes.

The very great and progressive loss of crop seen from Table II shows very forcibly the loss due to this extreme case of damage from the presence of jungle.

This plot in common with all the others received up to 12 light hoes annually before the experiment started. As soon as hoeing was stopped thatch began to invade from the drainsides, and before it is sickled this plot now looks like a thatch bari.

The extent of this invasion by thatch has not been uniform. A few patches still exist where only shallow-rooted, though

thick, grass grows. On these patches the tea is still relatively very good; while where thatch is really thick, the bushes hardly remain alive.

Plot No. 96 (3 light hoes, 3 rounds forking). This plot was, before the experiment started, giving 16 per cent. more crop than the check plot. This large difference was undoubtedly due to the increased yield from the line bordering the road, and this line still shows up as very markedly better than the inside lines. The outside lines of the other plots are alongside drains and suffer compared to inside lines. In spite of this advantage, the yield of this plot from having been 16 per cent. better than that of the check plot, has fallen progressively till in 1926 it was 8 per cent. worse. This drop is certainly significant.

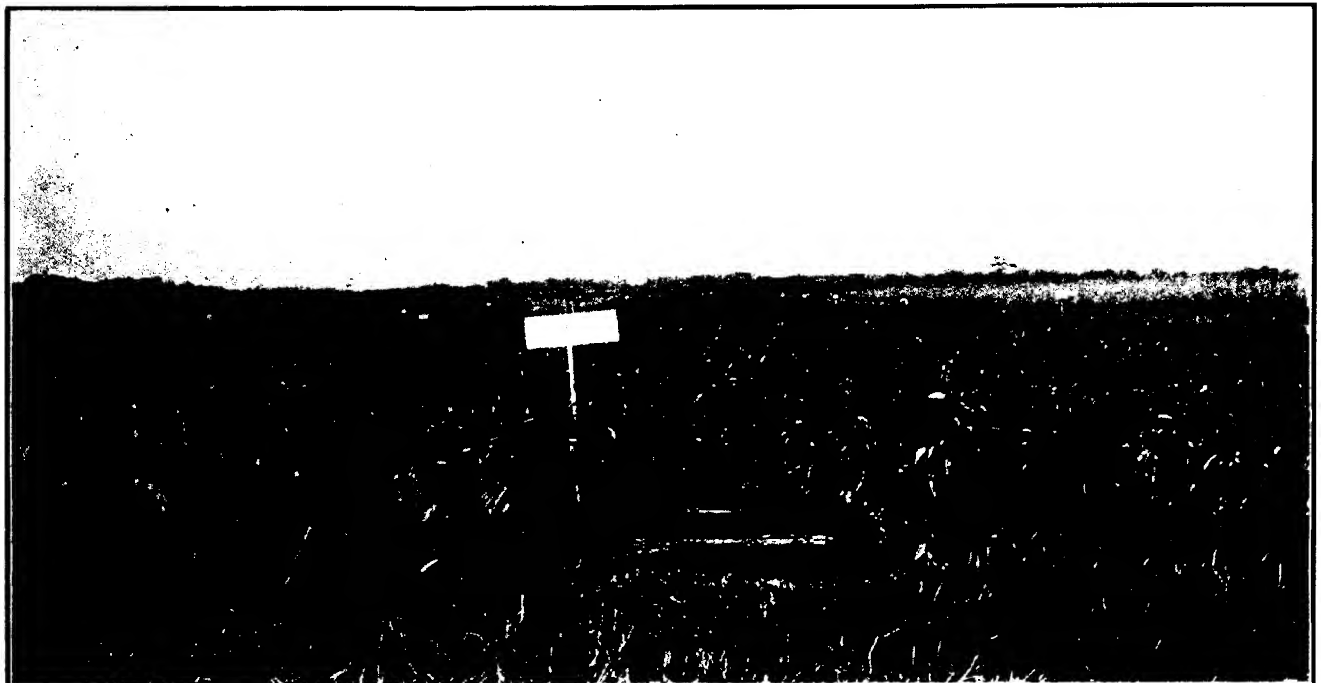
The cultivation which this plot receives differs from that of the check plot only in that three rounds of forking round the bushes replace the last three light hoes.

The first three light hoes, which both receive, are sufficient to prevent invasion by thatch. By the end of the season the check plot has only a very little light jungle evenly distributed; while plot 96 is quite clean over wide circles around the bushes, with narrow strips of low-growing, shallow-rooted, but thick grass between the rows. It is clear that the presence of this jungle between the rows is sufficient to reduce crop significantly and progressively.

1917-PLANTED MATELLI PLOTS 87 to 90.

On these plots yields appeared in 1921 to be fairly even (see Table IV), but there were large numbers of bushes still not being plucked or yielding little. It was therefore decided to give them another year, before starting experiments.

In 1922 when all were still under the same cultivation, yields varied greatly. This variation is frequently observed when tea is cut low. The way in which it comes away is largely a matter of accident and there is no doubt that cutting back ought to be avoided in plots under experiment. It is a great pity that



Plot 87.

Surface scraped only. Jungle on drain-side cut to show clean soil.

these plots were not given another year under the same treatment, particularly as the yields of the sub-plots in 1926 (Table III) show that the tea is very uneven.

The probability is that the tea was fairly even in 1921 and that the unevenness was produced by the cutting back of not very vigorous tea. Experience on other plots shows that after the cutting back, plots under the same treatment tend to revert to the same order of yield as given before the cutting, but that the effects of uneven " coming away " persist to some extent. Probably a fair index of the initial yielding capacity of these plots will be the sum of the yields in 1921 and 1922, but results from these plots up to the present must be regarded with a certain amount of doubt. As they are carried on, however, results will become more and more reliable.

PLOT NO. 87 (clean weeding).—In early 1923 it was attempted to keep this plot clean by hand weeding. This quite failed to keep down jungle efficiently, and a small relative drop in crop was obtained.

Later, Dutch hoes were tried. These, however, only uprooted the weeds, which, if rain fell, grew again, and the plot remained dirty with weeds.

In 1924, 1925, and 1926, the ordinary flat hoe has been used, once a month, to scrape all jungle into the middle of alternate lines of tea. The heap of jungle there largely rots and such as grows is scraped at the next monthly round into the middle of the next row previously left clean. The object of this work is to maintain soil free of weeds, without any stirring of the soil. This cultivation fulfils its object. From fairly early in 1925 practically clean soil has been maintained while the soil is stirred to a depth of less than one inch.

In spite of this lack of soil stirring it will be seen that while this plot yielded 13 per cent. less than the check plot in 1923, in 1926 it is giving 11 per cent. more than the check plot. (See Table IV.) It appears clear that as far as immediate crop

is concerned the suppression of jungle is of very great importance; and, in comparison, the stirring of the soil is a matter of small importance. Whether this plot will increase its lead over the hoed plot, or even maintain it, remains to be seen in the future. The stirring of the soil has been shown to be of benefit when organic matter, such as a green crop, is buried, and in tea cultivation, prunings are buried annually. There is considerable support, also, in general agriculture for the idea that the stirring of the soil, in the spring at least, is of value.

Any improvement from cultivation alone, also, must be made at the expense of the soil's reserve of food, unless this reserve is saved in some other way. It is possible that the avoidance of soil stirring may reduce the losses from washing out of soluble plant food, in which case the mere suppression of jungle may continue to prove effective. On the other hand the very effective suppression of jungle may lead to rapid soil exhaustion and deterioration of the tea unless manuring is increased. The future history of this plot will be watched with great interest.

PLOT NO. 88 (extra manure). In this plot the food denied to the tea bush by the presence of jungle due to lack of cultivation is partly made up for by the provision of soluble plant food as manure.

About the same amount of money is spent on this plot as on the check plot No. 89.

There is no need to bring any complicated arithmetic into service to show that the treatment of plot 89 (normal cultivation) has given better results than the spending of the money on manures while neglecting cultivation. (see Table III.) Under present conditions it is quite clear that five light hoes pay very much better than the same expenditure on manuring.

Labour however is becoming increasingly expensive and difficult to obtain, while manures are becoming cheaper.

Comparison of plot 88 with plot 95 is therefore of practical interest.

PLOT 88.

1 deep hoe, 1 light hoe in June and 1 round sickling in September but extra manure applied in June.
Photo taken 1 week after sickling in September.

FIG. 89. (CHECK PLOT.)

1 deep hoe. 1 sand picking. Eight hoes.

Left of Photo shows Plot 88, 3 months after last light hoe in June.

In 1926 the check plot for plot 88 (plot 89) gave 9.55 mds., while the check plot for plot 95 (plot 93) gave 10.16 mds. There is not much difference between the 1916-planted and 1917-planted tea of the same Matelli jat, and therefore they may be fairly compared.

Plots 88 and 95 get practically the same cultivation. The only difference is that in June, when both are hidden under jungle, plot 88 gets a light hoe which amounts to little, if any, more than the sickling which plot 95 gets at the same time. Yet in 1926, plot 88 gives 65 per cent. of the yield of its check plot, while plot 95 gives only 36 per cent., little more than half the crop. This difference of about 3½ mds. of tea is obtained for the expenditure of Rs. 25/- on manuring. One does not find such a difference from light manuring on moderately well cultivated plots.

In this case also one does not obtain the increase at the expense of the soil, but because of an addition to the soil which improves it. Where cultivation is deficient, there will the greatest gain from manuring be found. Plot 88 indicates that the presence of jungle deprives the bush of natural food, which may be supplied as artificials.

PLOT NO. 89, CHECK PLOT (one deep hoe and six light hoes). This plot is kept only for comparison with the other three plots of this series of experiments. It will be observed that one of the five sub-plots gives a yield far in excess of the mean of the whole plot. The other four contain no obvious bad patch of any extent. Sub-plot A is, apparently, on an exceptionally fertile piece of soil, so that the true relative yield due to this form of cultivation is probably rather lower than the mean of the five plots.

Incidentally it may be observed that the yield in 1926 from this 1917 planted tea (9.54 mds.) is not greatly different from that of the similarly treated plot 93 (10.15 mds.) planted in 1916. In 1921 the yields were, respectively, 5.34 and 6.22 mds. This illustrates the tendency of the plots to even up: plots which differed by 12½ per cent. in 1921, differ only by 6 per cent. in 1926, while the treatment has been identical for both.

PLOT NO. 90 (11 rounds forking). This may be considered to have been about equal to the check plot in yielding capacity when the experiment started. The maintenance of circles of absolutely clean soil by forking every month did not prevent a loss of crop roughly equal to the loss when about half or a quarter of the number of forkings were applied (plots 91 and 92).

By the end of 1924, this fact was considered sufficiently plain, and from the beginning of 1925 this plot received the same cultivation as the check plot, when the improvement was obvious, and will certainly become greater as the plot becomes freed of jungle.

Later on this plot will be used for other experiments. At present the recovery of poor tea by cultivation alone is well illustrated.

THE 1916-PLANTED SINGLO PLOTS.

Delicate light-leafed varieties like Singlo require a great deal of trouble and time to establish them at Borbhetta. On these plots the number of unproductive bushes in 1921 was great and varied greatly from plot to plot.

In this, the first tea planted at Borbhetta, great unevenness was produced by planting plot 78 first, when only good plants were used. The number of poor plants used became greater as the nursery was used up, so that plot 82 received a large number of poor plants which later had to be replaced.

The 1921 yield therefore gives no idea of the initial relative yielding capacities of the plots, since all the more poorly yielding plots tended to level up as bushes became mature.

This is made very plain by the behaviour of plot 81 which in spite of reduced cultivation made a relative improvement, compared to the check plot up to 1924. This is not so remarkable as it seems at first sight. At the end of 1921 all plots were absolutely clean having received unlimited cultivation to give them a fair start, and for a time there was not much more jungle on the plot receiving four light hoes (plot 81) than on the plot receiving six light hoes (plot 78).

The four light hoes applied to plot 81 are given at intervals of 60 days. Under this treatment they became increasingly infested with jungle, but only slowly, so that for some years the effect of increasing maturity of infillings more than counteracted the bad effect of the jungle.

The yields from these plots in the earlier years are therefore of little significance.

During 1925 and 1926 however the effect of cultivation had become the preponderating factor in influencing yield, and in considering the effects of different forms of cultivation, the yields in these years afford the most reliable means of comparison. Table V shows the yields of the individual sub-plots in 1926.

PLOT NO. 78, CHECK PLOT (1 deep hoe and 6 light hoes). The yields of the five sub-plots are in fair agreement, so that the mean yield may be taken as a fair basis for comparison with the yields of the other big plots.

PLOT NO. 79 (no deep hoe). This plot receives the same cultivation as the check plot except that since 1922, the check plot has received an ordinary deep hoe (to about 7 or 8 inches deep), while plot 79 has on the same day received only an ordinary light hoe to perhaps as much as 3 inches deep. The deep hoe buries all prunings and buries all jungle out of sight. The light hoe leaves the prunings exposed, and also some of such jungle as there is, though neither of these plots has ever shown much jungle at the end of the season.

In 1926 the apparent loss of crop due to neglect of deep cultivation for five years is so small as possibly to be not significant. Reference to Table VI shows that from 1923 to 1925 the plot without a deep hoe was giving a slightly higher crop than the plot not getting a deep doe. The reduced crop in 1926 may therefore be significant, indicating that after five years without a deep hoe plot 79 has begun slightly to deteriorate.

If that is so, this plot should continue to drop in crop, and future years will make this point plain. In the meantime it is

quite clear that this plot has gone without a deep hoe for five years with very little loss of crop, if any.

Depth of cultivation, on this soil at any rate, is thus proved to be of relatively little importance.

Plot No. 80, Trenching. This plot was trenched in 1922 in every other line, and in 1923 in the lines not trenched the previous year were also trenched; in each case to 18 ins. deep. In 1924, 1925 and 1926 it received exactly the same cultivation as the check plot.

It will be seen from Table V, that the yield obtained was 1½ mds. less than that from the check plot. Sub-plot A contains a bad patch, but even if this be neglected the mean of the other four sub-plots is still a maund less than from the check plots. This difference of about 10 per cent. may not be significant. It is possible that it may be due to initial difference in the fertility of the two plots.

It is however perfectly clear from these figures that the treatment received by plot 80, was certainly not better than that received by the check plot. That is, if the trenching in 1922 and 1923 ever did any good, the benefit did not last into 1926.

Referring to Table VI it will be seen that in 1921 this plot gave a crop very much below that of the check plot. Comparison is therefore more easily made with plot 79 which is immediately next to the trenched plot under consideration.

Since the evidence shows that this plot was not affected by the absence of a deep hoe, and otherwise had the same treatment as the check plot, plot 79 may be taken quite fairly as a comparison plot to determine the value of the trenching on plot 80.

In 1921, when both plots were under the same treatment plot 80 gave 90 per cent. of the yield of plot 79.

In succeeding years it gave the following percentages of the yields of plot 79.

1921.	1922.	1923.	1924.	1925.	1926.
90	91	87	94	89	90

It will be seen that the two plots have maintained practically the same relative positions. There is thus no evidence whatever that the trenching has produced any benefit. As has been explained, the general tendency in all the other plots has been for the originally poorer plots to even up towards the better plots in yield. The trenched plot has not shown this tendency, which might be taken as an indication that the trenching has done a little harm. This cannot be accepted as very definite evidence of actual harm from the trenching, but however the figures may be considered the evidence is quite conclusive that no benefit whatever has been gained from the expensive operation of trenching.

When records from gardens are studied, it is common to find that trenched areas do show some relative improvement compared to untreated areas, at least in the year immediately after the trenching. In such cases a good weight of green stuff of some sort has been put in the trenches, and from this manuring some gain is naturally expected.

In the case of these plots at Borbhetta, boga medeloa was cut from outside the tea, and the trenches filled before covering in with soil. The same weight of boga medeloa, however, was broadcast over the surface of all the other plots. All the plots, no doubt, gained from this manuring, but the manure was clearly at least as effective when merely deep-hoed or even light hoed in, as when buried in trenches.

The point is that when in garden practice benefit is apparent from trenching, the probability is that the benefit is purely from the manure applied and that in most cases the great expense of cutting 18 ins. trenches is merely waste of money, at best; while the danger of damage from cut roots makes trenching a very possible cause of definite harm. This opinion of course applies only to the general case where there is no "pan," layer of hard "kankar," or other mechanical obstruction in the soil. In such cases, there is no doubt, the obstruction must be broken; but it is strongly urged that labour should not be wasted on trenching, except where definite evidence of such obstruction has been obtained.

When a very heavy crop of Arhar, or boga medeloa has been allowed to grow, it is sometimes a matter of convenience to cut trenches in order to get the green stuff buried. In such cases, the trenches should not be more than 9 ins. deep. The manure will be more efficient at that depth, and the cost of making the 9 ins. trenches will be probably less than half that of 18 ins. trenches.

PLOT NO. 81 (four light hoes). Table V shows that this plot, in 1926, gave only 6.36 mds. of tea against 10.71 from the plot receiving six light hoes.

Sub-plot A contains a bad patch. If this be neglected, then four light hoes gives 6.84 mds. against 10.71 for six light hoes. There is no doubt whatever about the significance of this result.

Referring to Table VI, comparison is best made with reference to the adjoining plot No. 80, the treatment of which has been shown to have been, at best, no better than that of the check plot.

These two plots were not greatly different in 1921 before different treatment commenced.

Plot 81 has given the following percentages of the yield of plot 80.

1921.	1922.	1923.	1924.	1925.	1926.
96	87	94	95	77	69

It will be seen that, with the exception of 1922, the two plots maintained about the same relative position till the end of 1924. The drop in 1922, although the yields compared are very small, is probably significant. In this year the tea was cut to 8 ins. and provided little cover; so that, although the jungle was still of a good character, it became markedly more thick under reduced cultivation in the absence of cover from tea bushes.

It is rather remarkable that the effect of reduced cultivation, apart from 1922, did not make itself felt till after three years had elapsed. This is believed to be accounted for by the fact that both plots started very clean indeed, and that it took about three years for bad jungle to establish itself.

In 1925 and particularly in 1926, jungle, including a fair proportion of thatch, had become established and made its presence very definitely felt in greatly reduced crop, and in the poor appearance of the bushes.

PLOT No. 82 (eleven light hoes). This plot in 1926 gave one maund more crop than plot 78 receiving only 6 light hoes. The yields of the 5 sub-plots are in very fair agreement, and this difference is probably quite significant.

Reference to Table VI shows that in 1921, when both were under the same treatment, plot 82 was giving only 69 per cent. of the yield of plot 78.

Apart from improvement due to treatment the differences would have become less in succeeding years, as the originally smaller-yielding plot would have tended to even up. It is however very improbable that if the two plots had been kept under the same treatment they would by 1926 have attained equality in yield.

The real difference due to treatment is therefore probably rather more than the 9 per cent. actually found in 1926. That the real difference is not much more than that, is indicated by the small relative increase made since 1923.

The very big jump made in 1922, when the tea was cut down, again indicates the special value of cultivation at a time when the tea bushes are giving no cover to assist in keeping down jungle.

A very big jump also was made in 1924 when the tea was cut to 12 ins. This great increase in crop, however, was not maintained in the following year when the tea was cut at 18 ins.

From 1926 onwards the tea being only top-pruned will cover the soil more and more completely, so that the difference in crop due to 11 light hoes as compared to 6 light hoes is not likely to increase greatly in coming years.

That a greater difference from five additional light hoes has not been found may be a matter for surprise in some quarters.

Throughout these experiments when any two plots are compared, it is very apparent that the factor which has the predominating effect on crop is the presence of jungle.

On plot 78 the 6 light hoes are distributed so that they come at 40 days' interval throughout the growing season. On plot 82 the eleven light hoes come once a month, or at about 30 days' interval.

On these two plots which started clean, and now carry tea which is giving considerable assistance in keeping down jungle, the difference in the amount of jungle growth is not great. Hence if the suppression of jungle is the main benefit of cultivation little difference in crop from good wide tea would be expected from increasing the number of hoes from six to eleven.

That plot No. 82 shows no greater yield after all the extra stirring of the soil which it has received indicates that the mere act of stirring the soil can produce very little benefit, if any.

THE 1917-PLANTED SINGLO PLOTS.

In the case of these plots no evidence is available with regard to the initial yielding capacity.

The bushes were collar pruned, as ready, from March 1919 onwards and were plucked as they became sufficiently strong. In 1921 only half the bushes were being plucked so that the yields for that year give no information, but by the end of the year, as all the weaker bushes had been unplucked, the tea was fairly even in appearance.

As the tea was cut down to 8 ins. yields in 1922 were very small and are therefore again of little value; particularly as, still, only 85 per cent. of the bushes were being plucked.

In 1922 the maximum difference from the check plot was 16 per cent. and it can be assumed that the general tendency would have been to even up.

Any great difference in yield in 1926, therefore, may be quite certainly considered to have been due to difference in treatment.

Since two of the treatments used are such as do produce very great differences, the results are worth quoting, although in the case of the pair of plots showing only a small difference, it would be certainly wrong to assume that this difference is entirely due to difference in treatment.

PLOT No. 83 (3 light hoes and 8 rounds scraping). In 1923 this plot was used for a trial in the use of a wheeled hand-cultivator, which it was thought might prove of value in the cultivation of tea as it does of market garden crops which are planted in lines. It proved however quite ineffective in suppressing jungle growth, and reference to Table VIII shows that a loss in crop occurred under this form of cultivation.

From 1924 onwards this plot was used for a further trial of the scraping or "cheeling" already being tried on plot 87, but with a small variation. There is a very generally held view that stirring of the soil in the spring has a special value. In North-East India, certainly, there is at this time no fear of the damage by puddling the soil which might occur during the rains. This plot therefore is hoed during the spring, and cheeled during the rainy season.

It is hoped that, eventually, useful comparisons may be drawn between plots 82, 83 and 87.

All get the same cold weather cultivation in January, and all receive some other form of cultivation in the rains but—

Plot 82 is light hoed onced a month.

Plot 87 is "cheeled" once a month.

Plot 83 is light hoed in February, March, April, and cheeled in the remaining months of the year.

No direct comparison can be made yet, since the plots differ either in age or in variety of tea, but it is interesting to examine such evidence as is now available, by considering how each has already done with comparison to its own check plot.

It is probably best, in this case, to consider only the differences occurring in 1926, since by that time all plots had been under the treatment being discussed, for a year or two.

Plot.	Treatment.	Yield relative to check plot in 1926.
82	Light hoed 11 times	109
87	"Cheeled" 11 times	111
83	Light hoed 3 times Cheeled 8 times	159

These relative yields cannot be compared with any degree of accuracy, since the plots had been so different from their check plots in earlier years. From the difference of 2 per cent. between plots 82 and 87 certainly nothing can be inferred; but with respect to plot 83, the difference does appear too great to be due entirely to accident. The more complete suppression of jungle by cheeling instead of light hoeing probably gives it an advantage over plot 82; the stirring of the soil in the spring appears also to give an advantage over the mere scraping of the surface of the soil then practically clean; though the advantages spoken of are certainly nothing like so great as is made to appear by the figures above quoted. In later years, as the difference due to age of tea becomes of less effect, it should be possible to obtain a better comparison by considering the actual yields of the plots.

PLOT NO. 84 (deep digging with garden forks).—This cultivation is performed with the ordinary English garden digging-fork.

For the cold-weather cultivation the fork is pushed in by the foot perpendicularly to its full depth, and the clod is turned and broken, leaving the soil beautifully crumbly in appearance; and free of jungle.

During the rains this operation is repeated twice, but the fork being pushed in at an angle, the cultivation is more shallow, but still very complete and clean.

Between these rounds of cultivation the jungle grows very thickly. In consequence, in spite of three very efficient stirrings of the soil, the tea grows very poorly indeed.

Table VII shows that the yields of the five sub-plots are consistently very low, and the miserable appearance of the whole plot convinces any planter who sees it that some adverse factor has been in operation. This can only be the jungle growth.

Reference to Table VIII shows that this plot was originally not as good as the check plot but that a very significant further loss of crop occurred in the very first year of this type of cultivation, since when the tea has become worse and worse.

This is a very common type of cultivation in the Darjeeling district. As jungle would not grow so fast there, it may not do so much harm as it does at Borbhetta. There can be, however, no doubt that the inefficiency of the methods of jungle suppression practised in the Darjeeling district is a very large factor in keeping tea crop down to a low level.

The application of methods of jungle suppression which will not increase the loss of soil by wash is undoubtedly the most important problem for the Darjeeling district.

PLOT No. 85, CHECK PLOT (1 deep and 6 light hoes, all with flat hoes).—Table VII shows that the respective yields of the five sub-plots of plot 85 are not consistent. Sub-plots C and D both give yields about 13 per cent. below that of the mean of the whole big plot. Both contain tea well below the average of the remainder of the sub-plot, but both contain definite bad patches of small extent only, so that one is hardly justified in rejecting them.

It is probable however that this plot is for the greater part on poorer soil than for example plot 86, or 83.

As will be obvious from the yields of only 6 or 7 maunds obtained nine years after planting, this is very backward tea, and yields may level up as it becomes more mature, particularly as the disturbing influence of low cutting will not again act for many years.

PLOT NO. 86.—This plot gets the same cultivation as the check plot (plot 85) except that the work is always done with fork hoes instead of with the usual flat hoes.

In 1926 it gave a yield 15 per cent. greater than that of the check plot.

Although it is probable that plot 86 enjoys better soil than plot 85, there are no other cases on the station where adjoining plots, of size and shape similar to these, differ by as much as 15 per cent. when under the same treatment. It seems probable, therefore, that some part of the difference of 15 per cent. may be due to difference in treatment.

It is very difficult to guess in what manner cultivation by forks should be better than cultivation by flat hoes. Perhaps here, too, benefit may be obtained from additional stirring of the soil in the spring.

This plot does not provide any indication that fork hoes should be used in practice, rather than flat hoes.

The only way to ensure that the cultivation is the same for all plots is to endeavour to get every round perfect; that is, every bit of the surface is cut and turned over. To do this with fork hoes requires considerably more time and energy than with flat hoes; and the work done on plot 86 with fork hoes could, in practice, only be done at a lower rate per day than the work with flat hoes on plot 85.

SUMMARY AND CONCLUSION.

It is not possible, or desirable, from consideration of these experiments, to suggest that any one of the forms of cultivation tried is the best. Even if the best system of cultivating a particular block of tea could be settled definitely, available labour supply would generally render the application of the system impossible; or if it were possible, it might very well prove to be more expensive than warranted by the increased return. The main problem, as it affects most gardens, is to make the most profitable use of such labour as is available.

For this purpose it is very necessary for us to understand as clearly as possible the general principle of the way in which cultivation acts, so that attention may be focussed on factors of maximum importance, and resources not wasted on matters of relatively small importance.

Cultivation operations may do good in several ways :—

(1) By suppressing weeds.

(2) By stirring the surface, which should increase the efficiency of the aeration of the surface and also may be useful mechanically in mixing with the soil either manures, or green stuff, or prunings, or even weeds.

(3) By extending the effects of this stirring to greater depths, and, incidentally, increasing the depth of "good, dark top soil."

1. All through the experiments which have been described the effect on crop of keeping down weeds stands out in the most marked manner. Excessive growth of weeds leads extremely rapidly to enormous losses of crop; while, on the other hand, increase in cultivation beyond the point at which jungle is practically suppressed leads to very small increase.

2. There is some evidence that the stirring of the soil in the spring may do some good; and there can, from first principles, be little doubt that manure should be mixed with the soil and not left lying on the surface.

Apart from these cases it appears clear that the stirring of the soil must be an extremely small factor in crop production compared to the suppression of jungle.

3. The evidence appears to be complete that within a period of five years there is no gain whatever from any form of deep cultivation on this particular soil. If deep cultivation can be neglected for five years with practically no loss of crop then whatever may happen in the future, deep cultivation is obviously a factor of much smaller importance than jungle suppression.

Whether deep cultivation would prove to be so small a factor in all tea soils cannot, of course, be decided from these experiments.

It is very generally held for example that even if a sandy soil like that of Borbhetta can do without deep cultivation, yet a clay soil must be stirred to greater depths. Extensive experiments on this subject were made by the U. S. Department of Agriculture.* The results of the investigation are worth quoting.

" Such beliefs (in the necessity for deep cultivation) ap- " parently either overlook the luxuriant vegetation produced on " land that has never known the tillage implements of man or " assume that the roots of crop plants are essentially different in " their relation to the soil than those of other plants or of the " same plants growing wild."

" Sands and light sandy soils offer little resistance to the " entry and downward passage of water. They are little changed " and certainly not improved in this respect by cultivation. With " the heavier clay soils in which penetration is slower and more " difficult it would seem that there was more opportunity for im- " provement by a mechanical loosening. The result is not, how- " ever, what it might at first thought appear to be. The mechani- " cal loosening that may be effected when such soils are dry " enough to be loosened by tilling is of no consequence so long as " the soil remains dry. When rains come and water enters the " soil, it carries soil material with it in its downward passage " through the loosened soil. The clay expands on becoming wet " and the loosened and wetted area becomes an amorphous mass. " On drying, the soil contracts. A part of the shrinkage is down- " ward, and a part of it is lateral. The lateral shrinkage results " in cracks that may open the soil as effectively as any tillage " operation. Mathews* has shown that when allowed opportun- " ity for free expansion, a soil when wet may occupy 2½ times " the volume it did when dry."

" One cycle of wetting and drying overcomes the effect of
" cultivation. As Mosier and Gustafson* say—

" ' The subsoil ran together as soon as it was wet and
" ' became approximately as it was before.' "

" It is mistaking or failing to recognise the purpose of
" plowing that leads to the belief that its efficiency increases with
" its depth even though that depth be extended below all practical
" limits of cost and effort. Plowing does not increase the water-
" holding capacity of the soil, nor the area in which roots may
" develop or from which the plants may obtain food. Plowing re-
" moves from the surface either green or dry material that may
" encumber it, provides a surface in which planting implements
" may cover the seed, and removes or delays the competition of
" weeds or plants other than those intended to grow, and in
" some cases by loosening and roughening the immediate surface
" checks the run-off of rain water. All these objects are accom-
" plished as well by plowing to ordinary depths as by subsoiling,
" dynamiting, or deep tilling by any other method. There is
" little basis, therefore, for the expectation of increased yields
" from these practices, and the results of the experiments show
" that they have been generally ineffective."

" In their relative response to deep tillage there is no mark-
" ed difference to be observed between crops."

" These conclusions are the result of extensive experiments
" covering a wide range of crops, soils, and conditions in the Great
" Plains. Experiments conducted in the Great Basin under semi-
" arid conditions with the greater part of the precipitation occur-
" ring in the winter; under humid conditions in the States of
" Illinois, Pennsylvania, and Mississippi; under semiarid condi-
" tions at San Antonio, Tex.; and under semiarid conditions on
" the black soil of Southern Russia have all led to the same con-
" clusion : that yield cannot be increased nor the effects of drouth
" mitigated by tillage below the depth of ordinary plowing."

"The quite general popular brief in the efficiency of deep
"tillage as a means of overcoming drouth or of increasing yields
"has little foundation of fact, but is based on misconceptions and
"lack of knowledge of the form and extent of the root systems of
"plants and of the behaviour and movement of water in the soil."

Experience on nurseries shows that it is not quite true in North-East India, that "One cycle of wetting and drying over-"comes the effect of cultivation."

If a soil has been cultivated to a foot deep in say September or October before planting a nursery, then the disturbed soil is still found less compact than the undisturbed soil when the plants are lifted 18 months later, though no difference can be distinguished about 2½ years later. This point however is of little importance since the soil does not appear generally to be improved by this loosening.

From consideration of the evidence available it is perhaps still doubtful whether deep cultivation is of any value at all; but it is clear that its value is small compared to the enormously greater value of suppressing jungle. It is therefore urged that available resources should be devoted primarily to suppression of jungle, and that not until this object has been attained satisfactorily should labour be spent in such relatively unimportant operations as deep hoeing or trenching.

The ordinary deep hoe, of course, may be still be of value if it is found more efficient in suppressing jungle than the same amount of labour expended in light hoeing or on other forms of jungle suppression. At Borbhetta, certainly, one deep hoe is not as efficient as two light hoes, but on gardens which have been allowed to become very jungly during the growing season it may be found that the ordinary deep hoe (putting all jungle out of sight) has a greater efficiency than two light hoes, the completeness of which is not so easily checked.

At the present time the advice to suppress all jungle as completely as possible may be taken as a counsel of perfection, since

one's first thought is that this entails more light hoeing during the rains when so little labour is available.

What practical benefit, then arises from the deduction of these theoretical points?

Jungle may be suppressed by other means than hand labour, and the most efficient and easily provided means of suppressing jungle is shade. The planting of shade trees and cover crops will reduce the necessity for cultivation; but the most directly profitable method is to increase the cover provided by the tea bushes.

There are large numbers of areas scattered about the tea districts, where naturally rich soil has produced such fine growth of tea that the bushes cover the ground completely and nothing can grow under them. This is ideal tea, which requires the ideal cultivation—none at all. On poor or average tea, one cannot reach this ideal immediately; but, as this ideal is approached the necessity for cultivation will be more and more reduced. This of course means more manuring.

It has been shown that manuring will increase crop even from bushes growing among jungle. This crop comes from bushes of increased size, giving more cover. It has been shown also that correct manuring assists in replacing the coarser types of jungle by softer, shallower rooted, more easily suppressed jungle. The application of manures on a sufficiently large scale, accompanied by the concentration of available labour on whatever methods are found best to keep down jungle, is the general policy which is advised.

The use of shade trees will provide at least part of the manure very cheaply, and give also additional shade. Where a pan (or other obstruction to the passage of roots, water, and air) occurs, it must be broken; but it is waste of labour to trench or otherwise deeply cultivate all areas indiscriminately in case they may be panned. Roots will turn off horizontally from a pan, and this evidence should be looked for, before expending money and

labour on probably unnecessary trenching. Where plenty of labour is available crop will be produced more cheaply by increasing the rate of availability of the soil's natural stores of food by cultivation, than by adding manures. Such good cultivation, particularly on soils only partly occupied by tea and shade trees, must increase the rate of deterioration of the soil, and manuring will become, eventually, all the more necessary. Deterioration however would be very slow on soil fully occupied by bushes and shade trees, particularly if the soil were not stirred.

Clean soil appears to be the ideal on flat land.

On slopes, absolutely clean soil would greatly increase the loss of soil by wash; unless adequate protection is provided by such means as terraces, contour bunds, contour hedges, and systems of drainage which lead the overflow into safe channels. On unprotected slopes, the ideal would be the covering of the soil with a low-growing shallow-rooted leguminous plant, which, although it must reduce the available food supply would do so far less than the common tea garden weeds. Pending the establishment of such a plant, the practice now advised in Java and other tea districts appears the soundest which can be advised. That is, selective weeding. This means the eradication first of the arch-enemy thatch, and of other such coarse grasses as are noticed to be strongly growing and harmful; while plants such as Ageratum and dhoob-grass are left to hold up the soil.

With regard to thatch, some use may be made of the fact that it does not flourish in acid soils while tea does. The strongest thatch is found in soils of deficient acidity, which encourage the thatch, and discourage the tea. On such places the use of sulphate of ammonia not only strengthens the tea to smother the thatch, and discourages the thatch, but favours the growth of shallow-rooted plants to occupy the soil and retard re-invasion by thatch. As an extreme case, the application of a large dose of sulphur, on a small plot at Tocklai, has rendered the soil so acid, that no plant except tea will grow upon it.

TABLE I.

Yields in 1926 from 1916-planted Matelli Plots.

	Plot 91.	Plot 92	Plot 93. Check Plot.	Plot 94.	Plot 95.	Plot 96.
Cold weather cultivation	1 deep hoe, 1 round forking	1 deep hoe, 1 round forking	1 deep hoe (7″—8″), 1 round forking	1 very deep hoe (18″), 1 round forking	1 deep hoe, 1 round forking	1 deep hoe, 1 round forking
Rains cultivation	6 rounds forking (till end of 1925 after which, same as check plot).	2 rounds forking	6 light hoes	6 light hoes	Sickled twice	3 light hoes, 3 round forking
Yield of sub-plots in mds. pucca tea per acre :—						
A	6·94	5·23	10·90	9·82	4·35	9·04
B	6·21	6·27	10·65	9·03	3·65	9·57
C	7·91	7·40	8·64	9·95	3·13	8·73
D	6·09	5·89	10·32	9·77	3·49	9·80
E	7·68	5·42	10·29	10·83	3·77	9·66
Mean yield 1926	6·97	6·04	10·16	9·88	3·68	9·36

TABLE II.

Annual yields from 1916-planted Matelli Plots.

	Pruning inches from ground	1921 Unpruned	1922 Cut to 8"	1923 Unpruned	1924 Cut to 12"	1925 Cut to 18"	1926 Cut to 19"	Cultivation in 1922 and following years.
Plot No. 91	Mds. tea per acre	6·32	2·95	9·99	4·63	5·36	6·96	deep hoe } January-February. 1 round forking } 6 round forking, up to 1925. } during cultivation as for plot 93 in 1926. } season.
	Yield relative to plot 93 as 100	101	88	80	75	59	69	
Plot No. 92	Mds. tea per acre	6·95	3·03	10·49	4·37	5·16	6·01	deep hoe } January-February. 1 round forking } 2 rounds forking during season.
	Yield relative to plot 93 as 100	111	91	76	71	57	59	
Plot No. 93	Mds. tea per acre	6·22	3·33	13·92	6·13	9·09	10·15	deep hoe (7" to 8") } January-February. 1 round forking } 6 light hoes.
	Yield relative to plot 93 as 100	100	100	100	100	100	100	
Plot No. 94	Mds. tea per acre	6·41	3·85	14·76	6·11	9·02	9·86	very deep hoe (18") } January-February. 1 round forking } 6 light hoes.
	Yield relative to plot 93 as 100	103	105	106	100	99	97	
Plot No. 95	Mds. tea per acre	6·47	2·57	8·48	3·34	3·67	3·67	deep hoe } January-February. 1 round forking } sickled twice (June and September).
	Yield relative to plot 93 as 100	104	77	61	54	40	36	
Plot No. 96	Mds. tea per acre	7·22	3·99	14·28	7·11	8·84	9·34	deep hoe } January-February. 1 round forking } 3 light hoes. 3 rounds forking.
	Yield relative to plot 93 as 100	116	110	103	114	97	92	

TABLE III.

Yield in 1926 for 1917-planted Matelli Plots.

	Plot 87	Plot 88	Check Plot Plot 89	Plot 90
Cold weather cultivation	1 deep hoe 1 round forking	1 deep hoe 1 round forking	1 deep hoe 1 round forking	1 deep hoe 1 round forking
Rains cultivation	scraped (cheeled) 11 times	1 light hoe in June, following application of **extra manure**	6 light hoes	*1923 to 1924* 11 rounds forking around bushes. *1925 and 1926* 6 light hoes.
Yields of sub-plots in Mds. pucca tea per acre:				
A	10·18	7·05	12·61	9·33
B	9·07	5·57	9·92	8·82
C	11·78	6·83	8·82	7·77
D	11·53	5·53	7·94	7·08
E	11·42	5·81	8·39	7·75
Mean	10·60	6·16	9·54	8·15

TABLE IV.

Annual yields from 1917-planted Matelli Plots.

Years		1921	1922	Probable initial relative yielding capacity.	1923	1924	1925	1926	Rains cultivation in 1923 and following years.
Pruning (from ground)		Unpruned	Cut to 8″		Unpruned	Cut to 12″	Cut to 18″	Cut to 19″	
Plot No. 87	Mds. tea per acre	5·36	2·42	7·78	12·10	4·89	8·00	10·60	Various attempts at clean weeding.
	Yield relative to plot 89 as 100	100	81	94	92	87	95	111	From 1924 onwards, jungle scraped off with hoes once a month.
Plot No. 88	Mds. tea per acre	5·04	2·52	7·56	11·46	4·02	5·55	6·16	1 light hoe in June after broadcasting manure to value of 5 light hoes (Rs. 25) Sickled in September.
	Yield relative to plot 89 as 100	94	84	91	87	72	65	65	
Plot No. 89	Mds. tea per acre	5·34	2·97	8·31	13·19	5·59	8·47	9·55	Check plot.
	Yield relative to plot 89 as 100	100	100	100	100	100	100	100	6 light hoes.
Plot No. 90	Mds. tea per acre	5·68	2·80	8·48	11·31	4·11	(6·75)	(8·15)	11 rounds forking round bushes till end 1924.
	Yield relative to plot 89 as 100	106	93	102	86	73	80	85	Same as check plot in 1925 and 1926.

TABLE V.

Yields in 1926 from 1916-planted Singlo Plots

		Plot 78 check plot.	Plot 79.	Plot 80.	Plot 81.	Plot 82.
Cold weather cultivation.		1 deep hoe 1 round forking	1 light hoe 1 round forking	1922 & 1923 trenched 1 round forking 1923 to 1926 1 deep hoe 1 round forking.	1 deep hoe 1 round forking.	1 deep hoe 1 round forking.
Rains cultivation		6 light hoes	6 light hoes	6 light hoes	4 light hoes	11 light hoes
Yields of sub-plots in mds. pucca tea per acre.	A	10·70	11·00	7·76*	4·41*	11·71
	B	10·23	9·27	9·12	6·28	12·43
	C	11·05	10·44	9·61	6·99	11·33
	D	11·64	11·13	10·61	7·43	11·82
	E	9·93	9·73	9·24	6·68	11·21
	Mean =	10·71	10·37	9·27	6·36	11·70
or neglecting bad patches marked,*	Mean =	10·71	10·37	9·65	6·84	11·70

TABLE VI.

Annual yields from 1916-planted Singlo Plots.

Pruning (from ground)		1921	1922	1923	1924	1925	1926	Cultivation from 1925 onwards.
		Unpruned	Cut to 8″	Unpruned	Cut to 12″	Cut to 18″	Cut to 19″	
Plot No. 78	Mds. tea per acre	7·54	3·14	11·31	3·60	7·31	10·71	*Check Plot.* 1 deep hoe. 1 round forking. 6 light hoes.
	Yield relative to plot 78 as 100	100	100	100	100	100	100	
Plot No. 79	Mds. tea per acre	6·67	3·26	11·62	3·79	7·35	10·37	*No deep hoe.* 1 light hoe. 1 round forking. 6 light hoes.
	Yield relative to plot 78 as 100	87	95	103	105	103	97	
Plot No. 80	Mds. tea per acre	6·03	2·97	10·47	3·56	6·54	9·27	*Trenching.* *1922 & 1923.* trenched alternate lines. 1 round forking. *1924 to 1926.* 1 deep hoe. 1 round forking. *All years.* 6 light hoes, in rains.
	Yield relative to plot 78 as 100	79	85	93	99	88	87	
Plot No. 81	Mds. tea per acre	5·79	2·59	9·84	3·38	5·00	6·36	*Reduced cultivation.* 1 deep hoe. 1 round forking. 4 light hoes.
	Yield relative to plot 78 as 100	76	71	87	94	68	59	
Plot No. 82	Mds. tea per acre	5·30	3·10	11·72	4·80	7·54	11·70	*Increased cultivation.* 1 deep hoe. 1 round forking. 11 light hoes.
	Yield relative to plot 78 as 100	69	92	104	134	103	109	

TABLE VII

Yields in 1926 from 1917-planted Singlo Plots.

	Plot 83.	Plot 84.	Plot 85 Check plot.	Plot 86.
Cold weather cultivation	1 deep hoe 1 round forking	1 deep fork (1 ft.) 1 round forking	1 deep hoe 1 round forking	1 deep hoe 1 round forking
Rains cultivation	3 light hoes (Feb., March, April). 8 rounds cheeling	2 light forks (6 to 8 inches) all work with English long-handled garden fork	6 light hoes all work with flat hoes	6 light hoes all work with fork hoes
Yields of sub-plots in mds. pucca tea per acre				
A	11·47	3·03	7·22	7·86
B	8·92	2·21	6·00	6·30
C	8·74	2·22	5·39	7·25
D	9·27	2·46	5·23	6·41
E	10·14	3·47	6·85	7·41
Mean	9·71	2·68	6·14	7·05

TABLE VIII.

Annual yields from 1917-planted Singlo Plots.

Pruning inches from ground		1922.	1923.	1924.	1925.	1926.	Cultivation in 1923 and following years.
		Cut to 8″	Unpruned	Cut to 12″	Cut to 18″	Cut to 19″	
Plot No. 83	Mds. tea per acre ...	1·66	6·54	2·45	5·23	9·71	*1923* hand cultivator. *1924 and following years.* 3 light hoes. 8 rounds cheeling.
	Yield relative to plot 85 as 100 ...	96	89	109	113	159	
Plot No. 84	Mds. tea per acre ...	1·46	4·08	1·39	2·46	2·69	1 deep digging and 2 shallower.
	Yields relative to plot 85 as 100 ...	84	56	61	54	44	diggings with English garden forks.
Plot No. 85	Mds. tea per acre ...	1·74	7·28	2·26	4·55	6·10	1 deep hoe 6 light hoes all with flat hoes. Check Plot.
	Yield relative to plot 85 as 100 ...	100	100	100	100	100	
Plot No. 86	Mds. tea per acre ...	1·79	7·12	2·41	5·25	7·02	1 deep hoe 6 light hoes
	Yield relative to plot 85 as 100 ...	103	98	107	115	115	all with fork hoes.

A MAP OF THE TEA DISTRICT OF DARJEELING SHOWING THE PHYSICAL CHARACTERISTICS OF THE DISTRICT.

BY

E. A. ANDREWS.

The map reproduced in this issue of the Journal is one which the writer prepared, at considerable cost in time and labour, in order to acquire a proper appreciation of the physical characteristics of the Darjeeling district, the relationship of the different valleys to the district and to each other, and the difference in conditions in different parts of the area, more particularly during the monsoon period.

It has since been under frequent reference in discussing matters connected with tea in Darjeeling with planters and other interested people, and it has been found of great value in giving them a grasp of these characteristics and peculiarities of the district. It is very difficult, in a mountainous locality such as Darjeeling, more especially when vision is almost continually obscured in one, or all directions, by cloud or mist, to obtain any proper idea of the difference in conditions in different places, or even of the lie of the land. There are excellent Government maps, but they, again, are difficult to interpret without some knowledge of map reading, and even planters who have spent several years in Darjeeling have stated that this map has given them an understanding of the district they did not possess before. The map has been filed away for some time, with the idea of publication in a subsequent work on tea, but so many have suggested that it would be of value to many people to have the map for reference in the meantime that it has been decided to publish it in this Journal, for the benefit of such as may find it instructive and useful.

The map was prepared from the Government Survey Maps No. 78 $\frac{A}{4 \& 8}$ and No. 78 $\frac{B}{1 \& 5}$. These are on the scale of 1 inch to a mile. In reducing, the originals were carefully

divided into squares of 1 centimetre side, and a sheet of drawing paper carefully squared with squares of 1/10 inch side. Taking 1 centimetre as equivalent to 0.3937 inch, this reduces the scale to 0.2539 inch to 1 mile—which may be taken as ¼ inch to 1 mile.

In preparing the map the contours were carefully sketched in, square by square, and the course of the rivers was sketched in similarly, so that the map may be regarded as reasonably accurate. The map shows 1,000-foot contours, which can be identified from the scale of colours given at the side. It also shows the boundaries of the various geological series of rocks in the district. These were sketched in from the geological map published by the Geological Survey of India in the Memoir (vol. XI, pt. 1) by F. R. Mallet, "On the Geology of the Darjeeling District and the Western Duars." Thus, when the position of any garden has been located on the map, both its topographical and geological characteristics are indicated.

It will be observed that the whole of the Darjeeling district is not represented, but only the Western half, this being the area in which all the tea gardens (except one or two like Fagu and Kumai, which have their outlet into the Western Duars) are situated. This area forms a block which, omitting the high lands in the North-West corner, may be regarded as roughly 20 miles square, though owing to the mountainous nature of the district the actual area comprised within that square is increased. It is bounded on the North by the Ramman and Great Rangit rivers; on the East by the Teesta river; on the West by the hills of the Singalila range to the North and the Mechi river to the South, and on the South by the plains of the Terai. It will be noticed that the boundary between the plains of the Terai and the hills is a sharp one, and the hills, in fact, rise abruptly from the plains. The great Himalayan range is commonly divided into three zones —first, the great range of snowy peaks which form the axis of the chain; second, the Lower or outer Himalayas, a broad belt of lower mountains south of the snows; and the third, the sub-Himalayan zone, a belt of comparatively low hills forming ridges

and spurs either projecting from the Lower Himalayas or separated from them by the level valleys known as "Duns." The sub-Himalayan zone is missing in this district, and the tea district of Darjeeling is in the Lower Himalayan zone, which rises abruptly from the plains in this region.

The configuration of the district is clearly shown in the map. The Singalila range throws out a ridge, at an elevation of 7,000 to 8,000 feet which, lying in an east and westerly direction, extends from Simana-basti on the west to Ghum on the east. To the north of this ridge the land descends to the Great Rangit. To the south of the ridge the land descends to the plains. From near Ghoom three other hill ranges radiate. To the south, the Senchal-Mahaldiram ridge extends towards Kurseong, at an elevation of from about 8,000 feet towards Ghoom to 7,000 feet at the south, where it forks, one spur passing west of south, the other south-east and then east. Between the spurs forming this fork is the valley of the Mahanadi river, opening on to the plains to the south. To the west of the main Senchal-Mahaldiram ridge is the valley of the Balasun, also opening to the plains to the south, and bounded, still further west by a ridge passing south from the Singalila range, on the other side of which is the Mechi river. Smaller spurs thrown off by the Simana-Ghoom range and the Senchal-Mahaldiram range, delimit the tributary valleys of the Balasun—the Rungbong valley, the Nagri valley, the Sonada valley, etc.

From the main Senchal ridge another range, the Tukdah range, branches off, a little east of Ghum, and takes a north-easterly direction to the junction of the Great Rangit and Teesta rivers, ranging in elevation from over 7,000 feet near Ghum to less than 1,000 feet to the north-east. Subsidiary spurs from this range and the Senchal-Mahaldiram range divide the area between into the valleys of the Rangu, Rangjo, and Reaing rivers, all of which flow east into the Teesta river, the valley of which is a gorge passing almost directly north and south to open on the plain of the Terai.

A further range, the Darjeeling-Jalapahar range, extends northward from Ghoom at an elevation of between 7,000 and 8,000 feet to Darjeeling, where it forks and gives off two spurs, the Lebong spur and the Tukvar spur. Between this range and the Tukdah range lies the valley of the Rangu river, and to the west, between the Darjeeling range and the spurs of the Singalila ridge, the valley of the Little Rangit, both rivers flowing in a north-easterly direction into the Great Rangit.

The whole area may thus be regarded as composed of seven narrow river-valleys, radiating from a watershed in the centre of the district. Opening to the south are the valleys of the Balasun and Mahanadi; opening eastward are the valleys of the Rangu and the Little Rangit.

Thus, speaking generally, elevations decrease in all directions from the centre of the district, the valleys widen, and the hill slopes become less precipitous. The elevation of the centre of the district is, for the most part, round about 7,000 feet rising to 8,000 in places. At the boundaries on the north, east, and south the elevation is below 1,000 feet above sea level.

The tea gardens of Darjeeling are situated on the flanks of the various river valleys, and on the spurs projecting from the ridges between the valleys, at all elevations from the lowest to about 6,000 feet, though there is a little tea above this elevation. There is, however, no tea West of the Little Rangit river, and the whole of the Reaing valley, and the south bank of the Rangjo river, is given over to the Cinchona reserve.

It is easy to see, from a glance at this map, that conditions, during the monsoon (which is the growing season) may be very different in, say, the Balasun, Rangnu, and Rangu valleys, and that an adequate realisation of the position of any one tea garden, with reference to the whole complex, is essential to a proper appreciation of the special problems connected with the cultivation of tea on that estate.

The moisture-laden winds prevalent in the monsoon enter the district from the south. It therefore follows that the valleys

of the Balasun and Mahanadi, which open to the south, are fully exposed to them, whereas the winds, before reaching the valleys of the Rangjo and the Rangu, have been checked to a certain degree by the intervening ranges, and lost a good deal of their moisture, while after passing over the main watershed to enter the valleys of the Rangu and the Little Rangit they have lost even more. This is shown distinctly by the rainfall figures. For instance, the average rainfall, for 37 years, at Kurseong, situated in an exposed situation on the Senchal-Mahaldiram range, is 161.26 inches; the average rainfall, for 41 years, at Gielle in the Rangu valley, is 117.3 inches while the average rainfall at Ging, in the Rangnu valley, for 18 years, is 84.05 inches. These differences might possibly be intensified were it not for the fact that part of the monsoon wind also reaches the Rangu and the Rangu valleys by way of the Teesta gorge.

Not only is the rainfall controlled by the valley in which the estate is situated, but also by the position occupied by an estate in the valley. For instance, the head of the Rangnu valley, to reach which the monsoon winds have first to pass over the Ghoom Jalapahar range, affords an excellent example of the effect of situation on rainfall. Mineral Spring is on the lee-side of the valley directly beneath the crest of the range. The air passing over the ridge expands and descends on entering the valley, and is compressed and deflected upwards again on striking the Lebong spur on the other side of the river. In consequence, it is found that the average rainfall at Mineral Spring, for the five years, 1919 to 1923, was only 78.8 inches, while at Bannockburn, directly opposite, the average for the same period was 86.3. Beyond Bannockburn, to the north and further away from the Ghoom ridge, the rainfall gradually decreases, and at Ging the average for the same period is 77.8 inches.

Another feature which this map helps one to appreciate is the liability of different estates, or parts of estates, to mist. The mist line ranges between 4,000 and 4,500 feet and can distinctly be traced by following the contours.

The map also shows the range of the different geological formations. The whole of the centre and west of the district is situated on the Darjeeling gneiss. The lower ends of the valleys, and of the spurs between them, are situated on a series of rocks consisting largely of shales and slates, and known as the Daling Series. Across the centre of the Mahanadi valley is an outcrop of a mass of shales and sandstones known as the Damuda series, while gardens on the spurs to the extreme south are situated on a group of soft massive sandstones with pebbly formations often containing a considerable amount of lime, known as the Nahun Group. These differences in rock formation are accompanied by corresponding differences in soil composition.

Altogether, the Darjeeling district is unique in tea in North-East India, in the variety of problems it presents in the cultivation of tea, and it is hoped that this map, and the accompanying short description, may help others in co-ordinating and correlating their observations, as it has helped the writer.

VEGETABLE PARASITES OF THE TEA PLANT

(*continued.*)

THE BLIGHTS.

BY A. C. TUNSTALL.

Exobasidium vexans, Massee.

Blister blight, White Blister.

Refs.—

Watt and Mann, " The Pests and Blights of the Tea Plant," 2nd. ed., p. 387.

McRae, " The Outbreak of Blister Blight on Tea in the Darjeeling District in 1908-1909, Pamphlet No. 32, Indian Tea Association."

Butler, " Fungi and Disease in Plants," p. 422.

Petch, " Diseases of the Tea Bush," p. 51.

Indian Tea Association, Scientific Department, Quarterly Journals 1915, Part I, p. 15; 1921, Part IV, p. 209; 1922, Part II, p. 35 and 1927, Part I, p. 20.

Found in Upper Assam, Darjeeling and in a few gardens in the Dooars and the North of Surma Valley.

History.—Blister blight was first described by Mr. S. E. Peal in 1868. He stated that he had known it ten years before. It is probable that it is indigenous to Upper Assam. All sorts of theories were advanced to account for the disease. The most popular seemed to be that the sun caused the blisters. Unfortunately for this theory the disease thrives best in shady places. In 1895 however Mr. G. Massee of Kew definitely ascertained that the cause of the disease was a fungus which he named *Exobasidium vexans*. In regard to its distribution Watt and Mann made the following statement—" So far as we have

been able to observe, this blight is, and has hitherto been, exclusively confined to Upper Assam. It has never been definitely reported below the Jorhat District on the South and the North Lakhimpur District on the North Bank. It has never visited either Cachar, Sylhet, Darjeeling or the Dooars."

In 1907, however, the blight suddenly appeared in the Rungbong Valley of the Darjeeling District. In 1908 it was found all over that district except in the Teesta Valley which it reached in 1909. About the same time it appeared on a garden in Bhutan situated at a great distance from other infected tea gardens and not directly connected with any. It was also found on a number of other more or less isolated gardens, *e.g.*, Kerkeria in Mangaldai and Fagu in the Dooars. The infected gardens at the foot of the Hymalayas are widely separated but they had one point in common, they were each particularly exposed to winds from gorges directly connected with the higher ranges. In 1925 the disease was observed near Nigriting. In the same year it was also found at Numalighar a few miles further South. Late in 1926 the disease appeared on a few gardens in the Surma Valley. The first specimens were received from Mr. Gupta, Manager of Sabazpore Tea Estate. At first the disease only attacked the gardens in North Cachar and a few gardens on slopes facing East and North-East of the Longai and Hailakandy Valleys. By March the disease had extended to the other side of these valleys and southwards to the Chargola Valley. By May 1927 the disease was to be found scattered over the whole of the northern end of the Surma Valley. The attack was not serious and no time was lost in dealing with it. By the end of July the disease had apparently disappeared. It remains to be seen whether it will reappear in the next cold weather.

Description.—Blister blight usually attacks the young leaves but is also found on succulent green stems of the tea plant. The blight at first appears as round, translucent, pale yellow, sometimes pink, spots on the leaf. As the disease progresses these spots enlarge into white or pinkish convex warts, mostly on the

under-surface of the leaf. The opposite surface of the leaf is pale green, yellow or pink, with a concave depression. At a later stage these white convex warts shrink and darken into deep brown, almost black spots. These dried up spots sometimes crack and fall out, leaving round holes in the leaf. When several spots coalesce, or the disease attacks the mid-rib, the leaf becomes curled and distorted.

Examined by a pocket lens, the white surface of the spot is seen to be covered by woolly thread-like outgrowths having a powdery appearance. These are the fructifications of the fungus. A cross section of a spot will show under the microscope, that the cells in the convex part of the leaf have been pushed aside by the fungus, thus causing one side of the leaf to bulge. The cells of the diseased patch of the leaf contain less chlorophyll than the normal, and in some cases the cell contents are changed into reddish coloured substances. The filaments are mostly collected between the cells. Some of them, very much more fragile than the rest, enter the cells themselves. These filaments are divided by many cross walls.

The fungus can be grown in pure culture, but is very susceptible to high temperatures. The isolated spores of both kinds only survive a few hours, and no resting stage of any kind seems to be produced. It is very difficult to get the live blister blight fungus from Darjeeling to Assam. Blister on diseased leaves sent in the ordinary way through the post rarely survives the journey. The infection of the leaf takes place through the stomata, the little mouth-like openings on the under-surface of the leaf. The fungus is purely local, and each blister is the result of a separate infection. The fungus mycelium does not spread beyond the edge of the blister into the other tissues of the leaf or stem. The fungus, under ordinary circumstances, takes 10 or 11 days to develop from the time of infection to the formation of spores. It then continues to produce spores for seven or eight days when the disease dies away. This period is variable according to temperature. At high temperatures 80°-90° F, the fungus does not cause any appreciable damage.

At low temperatures 40°-50° F the development is very slow. The optimum for the fungus seems to be between 65°-75°F. The fructifications of the fungus arise from bundles of mycelium which push their way through the skin, forming a continuous layer of vertical filaments or hyphæ over the surface of the leaf. The end of each hypha or filament swells like a club. Some of these remain so, without undergoing any further change. In others the swollen end is separated from the rest by a wall, giving rise to a spore, known as conidiospore. This is the commoner form of fructification. In the early part of the season, and occasionally at other times, other filaments grow out 2 to 5 little horns called sterigmata. At the end of each of these horns a spore is formed. The filament with the horns and spores is called a basidium, and this kind of spore is called a basidiospore. This method of fructification is characteristic of the group of fungi to which Blister blight belongs. Other members of this group have special protecting devices, *e.g.*, the pores of the bracket fungi, or the gills of the mushrooms, etc. In the case of Blister blight the basidia are formed outside, on the surface, hence the name *Exobasidium*. The reason for the other part of the name—*vexans*—is obvious to planters. There are species of *Exobasidium* present all over the Rhododendron forests to the North-East of Darjeeling.

The conidiospores are usually single cells but occasionally are uniseptate.

The basidiospores are sausage-shaped, hyaline bodies. The size and shape vary considerably.

Blister blight not only attacks the leaves and shoots but also the young seeds. These are aborted and sometimes swell up to the size of a walnut. The fruits are not commonly attacked because they are not usually present at the time of the year when the disease is most prevalent. The fruits attacked by the disease never matûre.

Depredations.—A bad attack of this disease, once seen, is never forgotten. The whole of the succulent growth may be

destroyed. The rapidity with which it spreads is almost incredible. In a single night a whole hill side may become white. The more succulent the leaf the more susceptible it is to attack. It naturally follows therefore that the young growth on heavy pruned tea is particularly liable to damage. In the plains gardens the virulence of the disease varies from year to year but in the hill districts there is little variation. The cause of the variation has been traced to climatic conditions. It has been found that the fungus is particularly susceptible to the influence of temperature. High temperatures are fatal to the fungus and its spores. The normal temperatures of the air 80°-90°F in the plains districts during the rains are sufficient to kill the fungus. It has been found that the fungus in specimens of Blister blight sent by post from Darjeeling to Tocklai during the rains is invariably dead on arrival. It is only capable of survival in the plains during the hotter months of the year in cool shady places.

Remedies.—If the disease has been allowed to become prevalent on a garden it is useless to attempt to eradicate it until climatic conditions are unfavourable to the fungus. The most that can be done is to protect the young growth on cut back or heavy pruned bushes and young tea by spraying at frequent intervals with a fungicide, *e.g.*, Lime sulphur. This will prevent permanent damage to the plants concerned. When the weather becomes hotter the disease will die out in the plains districts in all places exposed to the sun and there is a chance of eradicating the disease by the careful removal of all diseased leaves from and the spraying of all tea bushes growing in shady places. Special attention should be paid to tea surrounded by jungle such as nurseries, particularly abandoned ones. Experience has shown that in the plains tea districts the disease is frequently harboured on stray tea plants growing in the jungle. The removal of all such plants from the jungle in the vicinity of infected gardens has repeatedly been accompanied by the disappearance of the blight from the garden concerned within a single year. In Darjeeling the best time to deal with the disease is in the dry season when little succulent leaf is present. The careful removal

of all blistered leaves at that time of the year will prevent infection of the young growth on pruned bushes in the early part of the season. In May or June however new outbreaks frequently occur. These should be treated at once by the removal of diseased leaves followed by spraying with Lime sulphur solution. This treatment should be repeated a week or so later. By prompt treatment of small outbreaks the blight can frequently be held in check until the succulent wood on pruned tea has hardened sufficiently to resist attack. When the weather is favourable to the blight however general infection cannot be prevented in the Darjeeling District.

Læstadia Camelliæ, Cke = ? *Læstadia Theæ*, Rac.
Copper blight.

Refs :—

Shaw, " The Copper blight of Tea. Ag. Jl. Ind." Vol. VI, Part I.
" Indian Tea Association, Scientific Department, Quarterly Journal," 1911. Part III, p. 7.

Butler, " Fungi and Disease in Plants," p. 443.

Petch, " Diseases of the Tea Bush, p. 34.
" Indian Tea Association, Scientific Department, Quarterly Journal," 1921. Part III, p. 168.

History.—In 1884 Cooke described a fungus found on some leaves sent to Kew from Johore. He found two kinds of fructification present and described them separately as two fungi. One of which he named *Sphærella camelliæ* a name which was subsequently changed to *Læstadia camelliæ* and the other *Phoma camelliæ*. The characteristics Cooke described apply to the two forms of the fungus which cause Copper blight in North-East India. Raciborski described a similar disease from Java and named the fungus *Læstadia Theæ*. Although a similar disease of tea had been known in North-East India for some time little

attention was paid to it until 1911. It was then considered to be identical with that described by Raciborski. Subsequently work on the fungus which causes Brown blight shewed that that fungus produced two forms of fructification one of which closely resembled that described as *Læstadia Theæ* by Raciborski. As the latter had noted that *Colletotrichum camelliæ* was present on the same leaves it seemed probable that the fungus he had described was the other form of that fungus. Petch draws attention to this confusion and suggests that the fungus which causes Copper blight is merely another form of that which causes Brown blight. The fungus which causes the disease known as Copper blight in North-East India is however quite distinct from that which causes Brown blight. The two forms of the Copper blight fungus have been reproduced the one from the other in pure culture and successful inoculations of tea leaves have been obtained from both kinds of spores. The two forms of the Copper blight fungus closely resemble the two forms described by Cooke as *Læstadia camelliæ* and *Phoma camelliæ* respectively and the name *Læstadia camelliæ* Cke, has been adopted. Some authorities prefer to use the name *Guignardia* instead of *Læstadia* on the grounds that the latter name had already been used for a species of flowering plants. The name does not matter very much to the practical planter. It is however of great importance to know that the disease known as Copper blight in North-East India is caused by an entirely different fungus from that which causes Brown blight.

Copper blight is found in all the tea districts of North-East India.

Description.—The first appearance of the disease is indicated by the formation of small, yellowish brown patches on the upper surface of the leaf. At this stage the leaf frequently bends over in a peculiar manner, exposing its under surface, which often assumes a coppery sheen. The colour of upper surface of the patches soon changes to a red brown. Later on these patches become larger and often irregular in shape, with a very ill-defined margin. At a later stage they become better defined

and darker in colour extending right through the leaf appearing as a yellowish brown patch on the under surface. As the disease progresses minute dots appear scattered all over the patches. The patches generally appear near the base of the leaf and enlarge and spread usually on both sides of the mid-rib.

When examined with a pocket lens both the surfaces of the diseased patches are seen to be studded with minute black dots, irregularly scattered in the neighbourhood of the veins. These black dots are the openings of round cases in which spores of the kind called pycnospores are produced. A section across such a spot will show under the microscope that the pycnidia are black, more or less spherical receptacles somewhat resembling those of Brown blight in external appearance, but differing in their contents. The pycnidia are produced singly or in groups and remain embedded into the leaf tissue with their mouths opening outside. From the cells of the inner wall of a pycnidium small colourless filaments grow out. These produce colourless one-celled, ovoid spores at their tips. When mature the pycnospores are detached from the cells of the inner wall of the receptacle. When fully ripe the upper portion of the pycnidial wall with its enveloping leaf tissue disintegrates, leaving a small crater-like depression.

This form of fructification is very common and may be found on diseased leaves throughout the year.

At a later stage when the surface of the spot becomes grey and brittle, a second form of fructification appears as minute black dots similar to but smaller than those mentioned above. On examination of a cross section of such a spot, under the microscope, it will be seen that these black dots are crater-like openings of spherical receptacles known as perithecia. The perithecia are black, more or less spherical shape with very short beaks. They are either scattered or in groups and are immersed in the leaf tissue, with their beaks communicating with the outside. They contain a large number of club shaped sacs (asci) each containing 8 spores (in this case called ascospores).

The asci are colourless, cylindrical and club shaped. The ascospores are also colourless, one celled, broad in the middle and slightly tapering at the ends. When young they contain a large number of refractive granules. They are arranged in two rows within the asci.

This form of fructification is less common and is only found for a few months (May to August) in the year and then only with difficulty.

The second form of fructification has been reproduced in pure cultures obtained from the spores of the first mentioned form.

Depredations.—The fungus infects the leaf when it is still young. It is more common during summer and the rains. It is most frequently observed about the time the second flush appears. It is not so common as Brown or Grey blights. The disease rarely causes severe damage.

Remedies.—Copper blight is not usually sufficiently serious to warrant remedial measures. If the attack is severe it is necessary to pluck off all the infected leaves and destroy them. If this plucking be followed immediately by spraying with a fungicidal mixture, *e.g.*, Lime sulphur solution, the infection of the young leaves is prevented. A second plucking is frequently necessary a day or two later but a second application of spray fluid is rarely necessary after the removal of infected leaves which had not developed obvious signs of the disease at the time the first plucking was carried out.

As the disease usually makes its appearance at the end of the first flush, it is generally possible to apply remedial treatment during the dry spell which precedes the heavy rains. When the disease appears in the heavy rains it is very little use applying spray fluids but if the diseased leaves are plucked off and destroyed there is little danger of serious damage being caused. Sometimes in Darjeeling the progress of the disease is very rapid, but when the disease spreads with such rapidity the diseased leaves generally fall off in a day or two and the young flush

comes away uninfected. Experiments have shown that under ordinary circumstances, *e.g.*, light shade and damp atmosphere the fungus mycelium survived the cold weather when in dead material. But solitary pycnospores when exposed to similar conditions could live only for 8 days. Exposure to direct sunshine was fatal to both, the former however survived for a few months while the latter succumbed within a day.

It is desirable therefore to remove at the time of pruning all dead leaves from plots which had been severely attacked by this disease during the previous season even when the disease has apparently disappeared.

Cercospora Theae.

The Shot-Hole Fungus.

Refs.—

Watt and Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 391.

Butler, "Fungi and Disease in Plants," p. 455.

Petch, "Diseases of the Tea Bush," p. 36.

History.—This disease was first described in Java and is also known to occur in Ceylon. It is present in all the tea districts of North-East India.

Description.—It causes small reddish brown spots, usually 2—3 m.m. in diameter. The centre of the spot dries up with age, becomes thin and turns white. It then falls out leaving a clean cut, circular, hole resembling a shot hole from which it has got the name of shot hole fungus. The fungus produces minute smoky-brown dots in the centre of the spots. These dots are the fructifications of the fungus, which are clusters of erect filaments bearing long slender spores at their tips.

Depredations.—This fungus occasionally infects the old leaves but it does not cause any appreciable damage to the bush.

Remedies.—No treatment is necessary.

THE INFLUENCE OF MANURING ON SUSCEPTIBILITY OF TEA LEAVES TO BROWN BLIGHT (*GLOMERELLA CINGULATA*) AT BORBHETTA.

By

A. C. Tunstall.

The present season has not been a very favourable one for Borbhetta. The pruned tea came away very well but later the young growth was severely checked by unfavourable weather and Rim blight was very severe on many plots. Other diseases, caused by vegetable parasites such as the Brown blight fungus, were prevented from doing any serious damage by the cold weather spraying with Lime sulphur solution and the bushes recovered from the Rim blight when the weather improved. About the middle of August, five months after the spraying, Brown blight appeared on some of the plots. It was noticed that the blight was more severe on certain plots manured with large dressings of nitrogen.

These plots cover four acres of Burma tea planted in 1920. This area is divided into 80 plots of 90 bushes each. There are no vacancies. There are 10 sets each of 5 plots similarly manured. The obviously infected bushes were counted in each plot on two occasions. The results of the two counts agreed very well and the results of similarly manured plots also agreed.

Percentage of infected bushes.

Total pounds of nitrogen per acre.	120	90	60	45	30	15	0
No manure.							
30 lbs. potash K_2O per acre 30 lbs. phosphoric acid P_2O_5 per acre and varying amounts of nitrogen applied in one dose at the beginning of the season	33·8	28·6	15·6	15·6	3·6	6·5	5·3

Percentage of infected bushes.—*Continued.*

Total pounds of nitrogen= per acre.	120	90	60	45	30	15	0
30 lbs. potash K_2O per acre 30 lbs. phosphoric acid P_2O_5 per acre applied at the beginning of the season ... ... Nitrogen applied at intervals in doses of 15 lbs. per acre	33·0	35·05	10	...	10·4	...	...
Equal amounts of potash, phosphoric acid and nitrogen applied at intervals in doses of 15 lbs. each	30·2	30·5	13·4	...	6·4	...	...
Average	32·3	31·3	13·0	...	7·1	...	...

N. B.—It should be noted that the plots most heavily manured with nitrogen yielded about 80 per cent. more leaf than the manured plots. It should also be noted that the above plots have been receiving the manures annually since 1924 and that this is the first time any noticeable differences in susceptibility to disease has been noticeable.

All the above plots except the check received potash, phosphoric acid and nitrogen. It is therefore impossible to judge the effect of nitrogen alone. The differences between the number of infected bushes on the plots receiving more potash and phosphoric acid and on those receiving less are too small to be significant but there seems to be a tendency for additional potash and phosphoric acid to reduce infection.

At Borbhetta there is another set of experimental plots—the Kharikatia plots planted in 1919 on which the manurial value of potash and phosphoric acid is being tested. The area is divided into 58 plots of 45 bushes each. There are ten sets each each of five plots and two sets each of four plots similarly manured. A certain amount of Brown blight was present on these plots but the attack was so slight that infection was not obvious

except in the case of one set. A different standard of infection had to be chosen for judging the infected bushes on this area. Three observers individually noted the infected bushes. Only those bushes which at least two observers noted were counted as infected ones. The results for similarly manured plots agreed very well although the observers were unbiassed by a knowledge of the manurial treatment.

The following table gives the percentage of infected bushes.

Potassium at the rate of 198 lbs. K_2O per acre.			Phosphorus at the rate of 94⅜ lbs. P_2O_5 per acre.		Calcium at the rate of 112 lbs. CaO per acre.		Percentage of bushes visibly infected.
Potassium chloride.	Potassium sulphate.	Potassium nitrate.	Superphosphate.	Basic slag.	Calcium carbonate.	Calcium sulphate.	
X	0	0	0	0	0	0	25.3%
0	X	0	0	0	0	0	10.2%
0	X	0	0	0	X	0	14.3%
0	X	0	X	0	0	0	12.4%
0	X	0	X	0	X	0	9.7%
0	0	X	0	0	0	0	23.9%
0	0	0	X	0	0	0	2.2%
0	0	0	0	X	0	0	8.4%
0	0	0	X	0	X	0	2.2%
0	0	0	0	0	X	0	10.6%
0	0	0	0	0	0	X	4.4%
0	0	0	0	0	0	0	4.4%

NOTE.—X indicates that the manure in question was applied.

All sets except the Potassium nitrate one received an annual dressing of dried blood (30 lbs. nitrogen per acre) for the last two years.

N. B.—It should be pointed out that most heavily infected set is yielding not less than 25 per cent. more leaf than the least infected area. It should also be noted that these plots have received the above mentioned manures annually since 1922.

From the above figures it appears that under the soil and other conditions at Borbhetta the bushes receiving heavy dressings of potash for a number of years were more susceptible to Brown blight than those receiving heavy dressings of phosphoric acid. A comparison of the yields however was not in favour

The percentage of disease was however insufficient to cause serious loss and the annual pruning and spraying was sufficient to keep the diseases concerned in check.

It is interesting to consider these figures with those in the previous article.

In all three series the plots with the highest yields were more seriously infected by disease. So far the disease has had no apparent influence on the yield.

METHODS FOR CONDUCTING EXPERIMENTS ON FACTORS AFFECTING THE QUALITY OF TEA.

BY

C. J. Harrison.

The demand in recent years for better quality teas has led to a greater interest in those factors which are known to affect quality, and attempts are continually being made by planters to investigate these factors and to modify and adjust them to suit local conditions. Such attempts involve experiments altering the various conditions in field and factory, the results obtained being compared with the outturn under normal conditions.

There are many pitfalls into which one may easily fall, in conducting such experiments, causing the results not only to be vitiated but in many cases to be productive of directly misleading conclusions.

It is our object here to indicate certain precautions necessary in carrying out experiments, particularly in the factory, on the quality of tea.

The intention of this article is not to discourage experiments in factories, by indicating the difficulties likely to be met with in carrying them out correctly, but rather to encourage such research and to assist in making the results more valuable.

It is hardly to be expected that all the conditions and precautions mentioned in the following pages can be complied with during experiments, though every effort should be made in this direction, and any irregularity in connection with the manufacture during the experiment should be borne in mind when assessing results.

It is hardly necessary to state that there must be constant supervision of the experiment either by the originator, or by some one who is keenly interested in, and understands thoroughly, what is being done. Experiments which are left in

sole charge, even for a time, of the average tea house staff, can never be relied upon, as it is extremely easy for samples to get mixed during the many operations involved in manufacture. Especially is this important during firing, subsequent sorting, bulking and handling.

The second important consideration is that a check experiment employing the normal methods, shall be run parallel with the test experiment, and that the conditions under which these two experiments are made shall not differ from one another except in the particular condition which is being tested. For instance, suppose that the thickness of spread in the fermenting room is under experiment. Sufficient leaf after withering for 2, 3, 4 or more rolls is bulked and divided into the required number of rolls, either as soon as it comes in from the garden or after withering. Each is withered, rolled, fired and sorted in precisely the same way. Each is fermented at different thickness of spread, at roughly the same time, in the same fermenting room and for the same period. The atmospheric conditions during the whole period should be kept constant as far as possible.

Similarly with other experiments, though modifications occasioned by limited machinery, have to be made.

It will be seen from the above illustration, that there are many "variable conditions." The chief of these are :—

(*a*) The material used,—in this case the tea leaf.

(*b*) The machinery and all apparatus connected with manufacture, including withering chungs and racks, fermenting floors, etc.

(*c*) Atmospheric conditions, including temperature, humidity, air supply or draught, light, etc.

(*d*) The distribution of the material, *i.e.*, thickness of spread, compactness depending on pressure in rollers, and fineness of division, or amount of breaking up of the leaf in rolling and sorting.

(*e*) The time taken over the different operations.

The first "variable condition"—the leaf used, is a most important one since the difference in quality of leaf plucked from two different sections, or even from two different bushes, may far outweigh any difference in subsequent treatment, and may result in erroneous conclusions being drawn.

Quality of leaf used.

Leaf for experiment should be plucked from bushes which have had as nearly as possible the same manuring, pruning, plucking, cultivation, shade, etc., and which are as nearly as possible of the same age and *jat,* and growing on a similar type of soil.

When it is possible to obtain such leaf in sufficient quantity, the difficult operation of bulking the leaf before manufacture is less important than when the leaf is somewhat mixed, although even in this case bulking should be carried out to ensure perfectly constant quality of leaf throughout the whole bulk.

The leaf coming in from the garden or from the withering chungs is tipped out onto a tarpaulin sheet, large enough to take the leaf spread about 6 inches—1 foot deep. Three or four boys then take handfuls of leaf from one corner to another and from the middle to the sides and so on. The corners of the sheet are then lifted up and the leaf shaken in a heap to the middle of the tarpaulin. The heap is again flattened out evenly over the tarpaulin. The separate batches of leaf are then taken up. This can be done best by using plucking baskets each holding about ½ md. of leaf. For one roll 10-12 basketfuls are required. These are filled up by taking handfuls of leaf from different parts of the sheet and when the batches of 5-6 maunds are collectlected, they are taken and spread on the withering racks, or to the rolling room as the case may be. Though this procedure seems somewhat absurd from a practical point of view it is our only way of obtaining reasonably similar samples of leaf with which to start the experiment.

It is probably better to bulk the leaf after withering provided the experiment is not in connection with this stage of manufacture. The advantage of bulking after withering is that less

damage is done to the leaf in handling, and any damage done has less harmful effects on the quality of final product.

Furthermore, differences in degree of wither may occur in different parts of the bulk, owing to some of it being spread at the edge of a chung, and some in the middle. These are eliminated by subsequent bulking. This must however be done quickly to avoid overwithering and it is perhaps advisable to remove the leaf a short time before it is fully withered, when dealing with large quantities of leaf.

Machinery.

Passing now to the second condition—the machinery, etc., used for manufacture,—with regard to the withering process the leaf may be spread either on wire racks or on hessian cloth chungs, but, unless the experiment is to compare the two, it is obvious that leaf for both check and test rolls, should all be withered on one or other—either all on hessian chungs, or all on wire racks of the same mesh. It will be found advisable not to use the racks at the sides or directly under the roof of the house, but those towards the middle where withering conditions are roughly the same all over. If an outside position is used, the extreme edges may receive an excess of sun or breeze or rain and be withered to a greater or lesser degree than the leaf on that part of the rack further from the edge.

As regards rolling, it is well known that rollers of different types produce quite different effects on the leaf. A single acting roller is less efficient than a double acting one, working for the same period under the same pressure and with the same number of revolutions per minute. It would also be unsafe to assume that a roller taking 6 mds. would produce exactly the same results as one taking 4 mds.

It is therefore safest to use rollers of the same make, and with tables of the same material, whether granite, brass or wood; similarly, kutcha sifters of the same type, whether rotary or flat, should be used throughout the experiment.

Although little difference has usually has been found to result from the use of cement, glass, or porcelain tiles in the fermenting room, it is always possible to use one type throughout the experiments, so to avoid possible question as to the accuracy of results, this should always be done.

With regard to dryers, considerable difficulty often arises in that one can seldom depend on two dryers, even of the same type, producing the same result on fermented leaf. Firing is such a complicated process that small differences in fan speeds, air baffles, tray speeds, spreader, and operations connected with heating the air, may produce considerable differences in the quality of resulting teas.

For this reason it is probable that the best method is to use the same machine for both check and test rolls. This can only be done when the samples of leaf are due to be taken from the fermenting room at intervals of at least ¼ hour. This will be the case when differences in time of wither, rolling or fermentation are being experimented on. Otherwise, when check and experimental samples have to be fired at the same time, it will be necessary to use different dryers. If however, the experiment is repeated two or three times, using each dryer alternately for check and test rolls, the net result will be a sufficiently reliable one.

One single experiment, even when carried out under ideal conditions, is insufficient evidence on which to base important conclusions, so that the more often an experiment is repeated, the greater becomes the value of its results. Furthermore, experiments should be repeated at different periods of the manufacturing season, since what may be true with regard to high quality June teas, may be untrue for average mid season teas, or autumnals.

Atmospheric Conditions.

The third of the variable factors, namely atmospheric conditions, is one of the most difficult to control throughout the experiment, and it is only by running check and test experiments simul-

taneously, or almost so, that differences due to this factor can be eliminated.

Actual climatic conditions have to be considered in connection with plucking of the leaf, the withering process and fermentation. Midday leaf is not of the same quality as evening leaf plucked from the same, or exactly similar sections, since the latter has been exposed to light and probably sunshine for a much longer period before plucking. The following analyses of leaf taken from the same bushes, at 6 A.M., midday and 6 P.M. on the same day indicate that differences in quality of teas made would occur to a certain extent.

Plucked at	Tannin %	Moisture %
6 A. M.	17·7	78·5
Noon	17·3	75·5
6 P. M.	14·0	74·5

Thus the leaf used throughout an experiment must all have been plucked at about the same time of day.

Climatic conditions, notably temperature and humidity, control withering to a great extent. It is impossible to rely on one day's wither being similar to the next. Thus, unless we can eliminate climatic changes from day to day by repeating an experiment over several days, we must see that the withering of both check and test manufacture, is carried out under the same conditions of temperature and humidity.

In rolling and fermenting, temperature, humidity, and amount of air control the rate of oxidation of the bruised leaf entirely. During the early part of the day, rolling and fermenting rooms are cooler and more humid than later in the day. If one sample is rolled and fermented more than half-an-hour before another, the two cannot be compared with confidence unless there is definite evidence that the temperature, humidity and atmospheric conditions generally have been the same in both cases.

It is necessary in fermenting, that the thickness of spread shall be the same throughout the experiment, since thickness of spread controls the air supply to the fermenting leaf. Similarly in the dryer, fan speeds, size of air inlet, and thickness of spread, each controlling the air supply, must be identical for all sets of samples to be compared, unless the factors mentioned are the ones under experiment.

In the fermenting room again, the question of light, though not of major importance, is worth consideration. Light itself may not appreciably affect fermentation but a spot in direct sunlight will generally be hotter than one in darkness. Rolls of fermenting leaf should therefore be placed roughly equidistant from any source of light.

Thickness of spread.
Pressure in roller.

By distribution of the leaf is understood firstly, the thickness of spreading or the area covered by a certain weight of leaf in the leaf house. In withering, a standard thickness of spreading should be one pound of leaf to one square yard. This is a standard which allows of even withering, and though perhaps impracticable on many gardens as a routine practice, should always be employed when experiments are being carried out. In fermenting, a general rule may be made of spreading the leaf the same thickness throughout each experiment; not less than $2\frac{1}{2}$ inches and not thicker than 4 inches, depending on the temperature of the fermenting room. If the spread is thinner than $2\frac{1}{2}$ inches or thicker than 4 inches, uneven fermenting is liable to take place.

A suitable spread of leaf in the ordinary endless chain type of pressure dryer, is obtained by adjusting the spreader to the lowest, or second lowest notch, so that a thin spread is obtained, and uneven drying in different parts of the trays is avoided. With thicker spreading, the air draught is baffled by the successive " blankets " of leaf on the trays, so that a steady air pressure is not maintained over the whole drying area. Where leaf happens to be spread rather more thinly, the air finds a passage through the trays more readily than in other parts, and

the thinner spread leaf is dried more efficiently than the rest. This is avoided by thin spreading universally.

The pressure exerted in rollers is another important factor which requires careful investigation, and so far, little has been done experimentally on this point. Unless the experiments are in connection with pressure, this should be the same for tests and check rolls and it will be found most convenient to employ the method in general practice. This is usually—

No pressure for first roll.
Medium pressure for second roll.
Heavy pressure; five or three minutes up and seven or ten minutes down } for third roll if any.

Marks should be made on convenient places on the rollers, indicating a certain degree of pressure whether hard or medium, and the cap can then be screwed down to the mark, to give the desired pressure.

Chalk marks may be made on one of the threads of the vertical screw so that when the horizontal chain wheel is level with any one of the marks, the required pressure is obtained. These marks should be in the same position for each of the rollers of the same type used.

With regard to the sorting of the finished tea, each sample should be put through the same machinery—sifters and breakers—so that each undergoes the same treatment throughout. It has been found very convenient with small experimental samples to produce only broken grades, by putting rough and fine mal mixed, straight from the dryer through a 3/8 Savage cutter and then through a flat type of sifter, giving the grades B. O. P., B. P., B. P. S., and P. F. If attempt is made to obtain leaf grades, samples will need to be of larger quantity than that obtained from one roll which never exceeds 1—1½ maunds pucca tea.

It is very easy during the many operations in the factory to get various samples mixed up or confused, unless care is taken

to mark each sample throughout manufacture. A useful method is to prepare small lead-foil labels about 4 inches by 2 inches in size, labelled so as to correspond with a separate list of the samples and their respective treatments. The lead labels should be placed with their respective leaf samples in the leaf house, on the rolling table, in the fermenting room and *through* the dryer directly before or after the respective " rolls " of fermented leaf. It will be found convenient to place one or two additional pieces of lead on the dryer trays immediately before and after a " roll " of leaf has gone in, thus avoiding any mixing of " rolls " in the dryer.

Again during sorting, bulking, and sampling, the different samples should be clearly marked.

The last and not least important part of the experiment is the comparison of the samples resulting from the experiment. Samples (roughly two ounces each) should be obtained, after careful bulking, of the rough and fine mal, the cut mal (after going through the Savage cutter), and each of the grades produced. Useful information particularly in connection with withering, is obtained by weighing and working out the percentages of the several grades, and this operation should not be neglected, even though it entails considerable extra trouble.

The small 2 oz. samples should be put in tins, marked clearly on top and bottom of the tin and on a label enclosed with the tea, and sent to a taster for valuation and report.

The marking should be simple and definite enough to prevent confusion. A taster usually does not want to know what the samples actually represent until he has completed his tasting, and prefers the samples marked simply :—

B. O. P. No. 1
B. O. P. No. 2

In sending the samples away, it should be clearly stated exactly what information is required with regard to the characteristics of the teas. A useful form of report to obtain from the taster is one which gives the following information.

Remarks on the liquors, leaf and outturn of rough and fine mals, cut mal, and sorted teas; together with valuations of the sorted teas, and of the cut mal, assuming the latter to be a Broken Pekoe Souchong.

The remarks made on liquors should include comparison between check and test sample of strength, colour, briskness, pungency, body, quality, flavour and creaming down. For leaf one requires a comparison of colour, size, tip (amount and colour of), twist, stalk. On infused leaf the colour, evenness, aroma are required.

Some tasters are able to tabulate the abovementioned characteristics and give marks indicating the degree of each characteristic present in each sample. Such tables have proved of immense value in experiments undertaken by the Scientific Department.

Of recent years it has been the practice of tasters in the big tea concerns, to visit various gardens in the tea districts during part of the manufacturing season. Managers should always be ready to seize any chance of carrying out experiments during the times when a taster is available on the spot, and it will be found that such experiments, carried out with taster and manager present, yield results of great assistance in improving prices and quality.

It is hoped, in a later article, to describe experiments carried out in recent years on the various stages in tea manufacture, and particularly in connection with the withering process.

The Department is always glad to receive particulars of experiments carried out in different factories on the manufacture of tea, and to offer any advice in connection with them.

THE EFFECT OF PHOSPHATIC MANURES ON SOIL ACIDITY.

BY

C. R. HARLER.

In the spring of 1926, extensive trials of phosphatic manures were carried out at Borbhetta. The test crop was mati kalai (*Phaseolus* spp.) and the results were reported in a previous number of this journal (Part IV, 1926). The experiments were carried out on 240 strips of soil and at the end of the year the acidity of each plot was estimated. The results of these estimations are shown below.

The acidity shown by the Hopkins method, the pH value of the soil solution and the pH value of the nitrate of potash extract obtained from the Hopkins acidity estimation were determined. It is necessary first of all to indicate, in general terms, the significance of these three constants.

The Hopkins acidity is estimated by shaking the soil with a solution of potassium nitrate and titrating the acidity thus produced in the solution. With the tea soils of North-East India, the action of the potassium nitrate is, mainly, to substitute some of the aluminium in the soil for potassium, thus bringing into the solution aluminium nitrate, which is acid. If there are plenty of soluble bases, like lime and magnesia in the soil, liberation of aluminium does not take place, and the soil is alkaline.

Soil acidity concerned with aluminium is known as the "mineral" type. Anything which removes the soluble aluminium or other weak bases from the soil reduces the acidity. Lime prevents the aluminium from coming into the soil solution. Phosphates precipitate the aluminium and thus remove it. The addition of potash salts brings aluminium into the soil solution

rendering it liable to removal by leaching. The ultimate result of potash additions is, thus, the reduction of mineral acidity.

The pH value of the soil is a measure not of the *amount* of the acidity present, but of the *strength* of the soil acid. It is possible to reduce the amount of the soil acidity, as indicated by the Hopkins figure, without reducing the pH value. Generally our best tea soils are those which are fairly acid, but, in a few cases, soils showing a low Hopkins acidity have grown excellent tea. These soils have shown a low pH value, *i.e.*, a strongly acid soil solution.

The pH value of the potassium nitrate extract is a figure on which this Department places considerable value. Its significance is not clearly understood and is difficult to explain in non-technical terms. When an acid soil is shaken with nitrate of potash solution, some of the aluminium in the soil minerals (mostly in the clay fraction) is substituted by the potash, and thus enters the solution as aluminium nitrate. This salt gives an acid solution with a pH value of 4.2, because it is composed of a weak base (alumina) and a strong acid (nitric acid). Nitrate of potash is neutral, pH = 7, because it is composed of a strong base and strong acid.*

When the potash attacks the soil constituents it substitutes not only weak bases like aluminium and iron, but also some of the strong bases like lime and magnesia in the form of carbonate. When such substances enter the soil it is equivalent to adding alkalinity, and the acidity is thus reduced and the pH value raised. If, then, the soil solution shows a pH value of 6, for example, and the pH value of the potassium nitrate extract reads much higher than this, say pH = 6.4, then we know

* NOTE :—The indication of acidity by the pH scale is at first confusing. Neutrality is indicated by pH = 7. Figures higher than 7 denote increasing alkalinity and figures lower increasing acidity.

Thus—

pH = 4.2 is more acid than pH = 5.4

and pH = 9 is more alkaline (or more non-acid) than pH = 7.5.

that the soil in question has a certain amount of loosely knit lime or alkali in its make up. Such soils almost invariably carry poor tea. If, on the other hand, a soil of, say, pH = 6 shows a pH value of about 5.4 in its nitrate of potash extract, then this soil may be a suitable one for tea, because it carries a reserve of acidity in its clay. If a soil behaving like the last one mentioned still carries poor tea, the reason must be sought in some factor other than soil acidity. Most good tea soils show a pH value of 4.2 for the potash extract, although the value varies from 4 to 4.8.

It now remains to show the effect of phosphatic manures on the acidity of the soil at Borbhetta. It was found that all phosphates which were active in promoting growth of mati kalai had made considerable reductions in the acidity of the soil. This was true of acid superphosphate, showing that the mineral acidity of our soils can be reduced, without the use of lime, by combination with phosphoric acid.

Since acidity varied greatly from place to place on the unmanured soil at Borbhetta, the apparent reductions recorded are not quite regular, but are sufficiently great to be very significant. The results quoted below are the mean reductions in acidity compared in each case with the unmanured check plot alongside.

The first table shows the result of using different manures adding, in each case, sufficient manure to supply 80 lbs. phosphoric acid per acre. Each result recorded is the mean of 6 separate pairs of observations.

The acidity varied all along the line of the plots, and the most accurate method for measuring the effect of different manures was obtained by comparing each plot with the adjacent check plot. These differences were then averaged and are shown below. A negative sign indicates a reduction in Hopkins acidity. In the case of pH values, a positive sign indicates an increase in pH, but a decrease in acidity.

Mean figures for all check plots were as follows.

	Hopkins acidity.	pH of soil.	pH of nitrate of potash extract.
	811	4·21	4·16

Mean change effected by various manures.

	Hopkins acidity.	pH of soil.	pH of nitrate of potash extract.
Basic slag	–283	+·3	+·1
Belgian phosphate	–232	+·3	+·1
Superphosphate	–158	+·2	0
Algerian phosphate	–142	+·2	0
Bone meal	–141	+·1	0
Indophos	– 92	+·1	0
Singhbhum phosphate	– 33	0	0
Plutophos	+ 37	0	0
Radiophos	+ 18	0	0

Changes of 50 or less in an acidity of about 800 have little significance so far as the Hopkins figure is concerned. It will be seen that although superphosphate lowers considerably the Hopkins acidity, it has a relatively small effect on the pH value of the soil.

The second table shows the result of adding increasing quantities of some of the different manures. Each result recorded is the mean of five separate observations.

Mean figures for check plots were as follows.

	Hopkins acidity.	pH of soil.	pH of nitrate of potash extract.
	692	4·80	4.2

Mean changes effected by varying quantities of manures.

Phosphoric acid per acre.	Change in Hopkins acidity.	Change in pH of soil.	Change in pH of nitrate of potash extract.
20 lbs. as Basic slag	− 88	+·5	+·1
40 " "	− 98	+·2	0
60 " "	−134	+·4	+·1
80 " "	−256	+·8	+·2
120 " "	−360	+·8	+·1
160 " "	−349	+·7	+·1
40 lbs. as Belgian phosphate ...	− 75	+·4	0
80 " " " ...	−100	+·4	+·1
120 " " " ...	−125	+·5	+·1
160 " " " ...	−173	+·8	+·1
240 " " " ...	−202	+·6	+·1
40 lbs. as Radiophos	−15	+·2	0
80 " "	−18	0	0
120 " "	+ 6	+·4	+·1
160 " "	−47	+·4	0
240 " "	+19	+·5	0

The figures are not quite consistent but it is clear that both basic slag and Belgian phosphate reduce all forms of acidity significantly and progressively. Radiophos effects no appreciable change in the Hopkins acidity but raises the pH slightly.

Since even acid superphosphate lowers the Hopkins acidity the phosphoric acid in radiophos, if it reacted with the soil at all, would be expected to lower the Hopkins acidity. The failure to alter the Hopkins acidity confirms the results obtained with this manure on mati kalai, showing that this phosphate is inactive in the soil.

Phosphatic manures must be regarded as an important factor in the acidity problem of the tea soils of North-East India.

PROPOSED TOURING PROGRAMME OF THE OFFICERS

OF

THE SCIENTIFIC DEPARTMENT.

Season 1928.

Months.	P. H. Carpenter.	H. R. Cooper.	C. R. Harler.
January ...	Dooars	......	Dooars
February ...	Board of Agriculture	Doom Dooma & Margherita	Jhanzie
March ...	Calcutta ...	......	Moran
April ...	Nahorkatia & Tingri	Nowgong & Kamrup	......
May ...	Bishnath & Boroi ...	......	Orang & Tezpur
June ...	Calcutta ...	Happy Valley ...	......
July ...	Juri, Doloi, Lungla ...	......	Panitola & Dibrugarh
August ...	South India ..	Dooars	......
September ...	......	Terai & Darjeeling ...	......
October ...	Calcutta ...	......	Longai & Chargola
November ...	......	......	.....
December ...	......	......	......

Mr. Andrews and Mr. Benton will tour as the investigations which they are making will necessitate. Mr. Tunstall and Mr. Harrison will be on Home Leave.

The exact date on which the above tours take place will be given later to the respective sub-district Chairmen. Managers desiring a visit from the scientific officer must inform the sub-district Chairman who will make out an itinerary for the touring officer.

TEA IN JAVA.

BY

C. R. HARLER.

The account of tea in Java which follows, does not pretend to be a comprehensive description of the industry in that country. It is largely an elaboration of notes made during a visit to the tea districts of Java, referring mainly to differences between methods in that country and North-East India.

Whilst in Java, I was shown every courtesy and kindness. Mr. Lagmans of Geo. Wehry and Co., showed me something of the business side of the tea industry in Batavia and introduced me to the Tea Expert Bureau there. Dr. Bernard, chief of the Tea Experimental Station at Buitenzorg, arranged an itinerary on my behalf, and thus gave me the opportunity of seeing typical estates in the various tea areas. At Buitenzorg I met the scientists engaged on tea problems and discussed subjects of common interest with them. Messrs. Garretsen and Keuchenius, of the Theeproefstation staff, took me to estates round Buitenzorg, Soekaboemi, Bandeong and the Pengalengen. I was also shown the tea seed gardens and selection work being carried out at Tjinjiroean on the Pengalengan plateau.

I take this opportunity to thank these gentlemen for their kindness, and also to thank the various estate managers for their hospitality, and the trouble they took in showing me their estates and factories.

I am aware of the danger of generalising from impressions, and took care to verify most of my statements with members of the Experimental Station. It is thus possible that many of the statements made in this account may be the ideals suggested by the scientists at Buitenzorg, to which the actual practices in Java only approximate. I know from my own experience that in speaking to strangers about methods employed on tea gardens in Assam, I am apt, unconsciously, to describe things as they should be rather than as they actually are.

THE DUTCH EAST INDIES.

The Dutch East Indies is the collective name for a series of islands and island groups stretching from Further India to Australia. These islands are situated between 75° and 141° east longitude, and between 6° north and 11° south of the Equator. The Dutch name for this area is Nederlandsh-Indië. It is difficult, at first, to realise the extent of this island empire. The maximum length from west to east, *i.e.*, from Sabang, in Sumatra, to Humboldt Bay, in New Guinea, is about 3,125 miles. From north to south the maximum distance is is about 1,250 miles.

The Netherlands Indies comprise the large islands of Java and Sumatra, the greater part of Borneo, Celebes, the western part of New Guinea and innumerable small islands. The island of Timor belongs partly to Portugal. The total area under Dutch control is 733,681 square miles and this is inhabited by over 51 million souls (census, January 1926). The table below gives a survey of the area and population of the four largest islands and of the remainder of the area, which is largely made up of Dutch New Guinea.

	Sq. miles.	Population.
Java ...	... 50,762	36,403,833
Sumatra ...	... 162,268	6,218,724
Borneo (Dutch)	... 213,589	1,757,963
Celebes ...	... 71,763	3,314,344
Rest of archipelago	... 235,299	3,319,014
Total, Dutch East Indies	733,681	51,013,878

The Dutch East Indies are about fifty-four times as big as Holland. A further idea of the size of this empire is given by comparing it with the total area of the British Isles, which is 121,000 square miles.

Although Java is, as yet, the only well developed island, Sumatra is progressing rapidly and, with the other islands, will

in time go to make this area one of the richest in the world. All the islands of any size are connected by regular Dutch steamer services which run with a remarkable punctuality. Dutch lines also run from Java to Europe, Australia and the Far East.

Up to now the economic development of the Dutch Indies has been bound up with agricultural products. Native agriculture has for its chief object the supply of foodstuffs to the inhabitants, whilst estate agriculture works almost exclusively for export. The chief native crop is rice, followed by maize, then tapioca, sweet potatoes, pea nuts and soya beans. One of the most important estate products is rubber, of which about a million and a quarter acres are planted, partly in Java and partly in the other islands. The total output of this commodity is more than 35 per cent. of the world's production. Sugar, coffee, tea and tobacco are also large industries. Java possesses almost the monopoly of cinchona and more than 90 per cent. of this product placed in the market comes from the island.

Politically the Netherlands Indies forms part of the Kingdom of the Nederlands and the Dutch legislation is the highest lawful power. Practically speaking, however, only when laws concerning the economic situation are in question is the Home influence exerted. With this exception, the colony enjoys administrative self-government on a large scale. The supreme power is in the hands of the Queen of Holland who rules in accordance with Government regulations. The Governor-General rules in name of the Queen, and he is assisted both in his legislative and executive power by an official advisory body, the Council of the Netherlands Indies.

In 1918, a representative body known as the "Volksraad" (People's Council) was formed, members of which are partly elected, and partly appointed by the Governor-General. The latter can consult this Council on all matters, but is obliged to do so on such matters as budget, colonial loans and military obliga-

tions of the residents. In 1925 the competence of the Volksraad, in regard to legislation and budget, was considerably extended.

Administratively the territory is divided into residencies, each controlled by a resident with subordinates under him. In the villages, the natives are largely controlled by their own chiefs, the Dutch civil service only supervising the native government.

Java is by far the most important island in the archipelago. Its length, from east to west, is 665 miles and its breadth varies from 33 to 120 miles. In size, it is slightly smaller than England and Wales and in population it is also slghtly less. The island lies entirely between the 6th. and 8th. degrees of south latitude, and is hence situated about as far south as Ceylon is north of the Line.

The flora of Java is tropical and resembles very much that of the wet part of Ceylon. In the mountain region a subtropical vegetation occurs.

The subterranean soil is ancient rock broken by many volcanoes, for Java is situated on or about one of the great fissures in the earth's crust, and the volcanoes form one of the outstanding features of the island. There are about fifty volcanoes in Java and the upper layers of the soil are, for the greater part, composed of volcanic material, generally of recent geological origin. Buitenzorg is situated between two magnificent cones, Salak and Gedek, both well over 6,000 feet high, and on the flanks of these two volcanoes many estates are situated.

The ascent of a volcano is an interesting experience. Round the base of the cone the vegetation is tropical and dense but towards the top it becomes stunted and small leaved. Finally all vegetation ceases and the track leads across pumice and scoria to the crater's edge. The atmosphere along the path to the crater is charged with sulphurous fumes.

The large craters present an inspiring sight, not only on account of their size and depth, but also because of the constant rumble and roar of the troubled, boiling mud pools deep down in the centre, which emit gusts of sulphurous steam.

In Java there is a volcanic service, the function of which is to observe the nature of the activity of the volcanoes. Twice daily temperatures in the craters are taken, and it is possible from these, and other observations, to predict eruptions.

Batavia, the capital of Java, has a population of 354,737 of whom 37,053 are Europeans. The other ports are Sourabaya with a population of 248,961 and Samarang with 150,952 inhabitants. All these three cities are on the low northern coast of the island. Soerakarta and Djokjakarta are large inland towns and centres of Javanese life and custom. Bandoeng is a modern town in the centre of the island, situated at the base of the Pengalengan plateau at an altitude of about 2,000 feet. Its position and climate are extremely pleasant, and this spot is a favourite one for Dutch people who retire and settle in the island.

The communications in Java are excellent. Railways and steam tramways run all over the island. From Priok, the port of Batavia, to Weltevreden, the modern city, a distance of about seven miles, the line is electrified, and the electrification is being extended to Buitenzorg, 38 miles inland. Such an extensive system of excellent metalled roads has been constructed that there is practically no place of any importance which cannot be reached by motor, over a good road. Canals are used in the lowlands and, largely on this account, the country is frequently likened to Holland.

A complete telephone system is in use, and there are several wireless stations in Java, and others scattered throughout the Dutch islands.

The native inhabitants of Java are of the Malay stock and are Mongolians. Chinese and Arabs are the most numerous of the foreigners present, although the Europeans total 176,806. The great majority of the native population are Mohammedans which faith was first introduced by the Arabs in the fifteenth century. Prior to this, the Hindu influence had been great, as is evidenced by the magnificent temple at Borobudur

and other remains found in various places, relics of a former Hindu-Javanese empire.

THE TEA INDUSTRY IN JAVA.

The introduction of tea into Java and the subsequent development of the industry was along lines parallel to those followed by the industry in India. In about 1690, Camphuys, the Governor-General of Java, planted the first tea in that country purely as a matter of interest, just as Captain Kyd did in India, in about 1780. In 1728, the Dutch East India Company seriously considered the planting of tea in Java as the British company did in 1788. Neither of these schemes were carried through and it was not until 1825 in Java and 1835 in India that tea, as an industry, may be said to have started.

In 1825, the Dutch Government ordered tea seed from Japan through the renowned expert on things Japanese, von Siebold, and during the following years increasing quantities of both China and Japan seed were imported into Java.

In British India, tea plants were brought from China in 1835 and planted at Kumaon. This step was activated by the fact that the monopoly of the tea trade with China, previously held by the British East India Company, expired in that year. Although Bruce had discovered tea growing wild in Assam in 1823 it was not until a scientific deputation had visited that country in 1835-36 that the tea project moved thence.

The industry in Java did not advance so steadily as in North East India, for it is only comparatively recently (from about 1900) that Java teas have become an important factor in the world's tea market.

In 1832 the Dutch Government, realising the possibility of tea as an industry, brought expert tea makers from China to work in Java. The results were not successful. In 1838 an establishment for the finishing of tea was established in Batavia, presumably in accordance with Chinese methods. Owing, however, to difficulties of transport, the final treatment was often not given until several months after the preliminary manufac-

ture, and this naturally caused serious deterioration in the quality of the product. The result was that the tea was sold at a loss which, between 1835 and 1860, became so serious, that the Government abandoned its direct connection with the industry as existing contracts expired.

In 1865 several estates were rented to private individuals in the Preangers and others were opened out. The quality of the tea, however, was still inferior and could not compete with that of British India. In about 1878, hand manufacture was replaced by machinery and considerable improvement in quality was thereby effected.

Assam seed was first imported in 1872 although the first real success with this seed was not obtained till 1878. It is reported that Assam seed was imported from Ceylon to Java as early as 1877, but, as the plants proved scarcely different from "Java" or China tea, the experiment was given up. During the tea rush in the 'eighties, more Ceylon seed was imported with no more encouraging results than before. The Assam plant has been so successful in Java that it has now become the standard type in the island.

In 1882, the society known as the Soekaboemi Agricultural Syndicate was formed with the object of looking after the interests of the tea and allied industries in Java. During the 'nineties the Government took a great interest in tea and deputations visited India and Ceylon, which led to changes in Java methods. In 1902, a Tea Experimental Station was established by Government.

The growth of the industry is illustrated by the exports during the last quarter of a century.

1901	export	16,750,000	lbs.
1905	,,	25,500,000	,,
1910	,,	40,000,000	,,
1915	,,	101,000,000	,,
1920	,,	93,700,000	,,
1925	,,	94,800,000	,,

The break from the steady increase in 1920 was due to the post-war slump in tea prices, following on a period of over production. Exports are now again steadily increasing and at a much faster rate than those from either India or Ceylon. In 1925, Java and Sumatra exported over 111 million pounds, in 1926, over 136 million pounds and in 1927, over 145 million pounds.

At the end of 1925 there were 194,439 acres under tea in bearing in Java, and 26,621 acres in Sumatra, although in the latter country about 32,000 acres were planted. Of the 285 tea estates in the Dutch Indies, 260 are in Java and the remaining 25 in Sumatra. Although there is practically no more land available for tea cultivation in Java, extensive tracts in Sumatra have been found suitable for tea. In 1911, only 500 acres were planted in this latter island, but the success was such a signal one that the area has steadily increased. Most of the Sumatra estates are on the east coast, but areas on the west coast are now being fast opened out. The annual tea output of Sumatra is at present about 18 million pounds, and a great increase is to be expected in the next few years.

In 1926 the yield per acre was about 700 lbs. tea in Java and 650 lbs. in Sumatra, against about 600 lbs. in North-East India.

The position of the tea crop from the Dutch Indies in the world market may be gauged from the export figures shown by the principal tea countries during 1926.

British India	export	337	million	lbs.
Ceylon	,,	207	,,	,,
Java	,,	118	,,	,,
Sumatra	,,	18	,,	,,
China	,,	111 (?)	,,	,,
Japan	,,	23	,,	,,
Formosa	,,	22	,,	,,

Regarding the price of Java teas, it is difficult to get a direct comparison with tea from other countries, since only part of the

Java crop, and that probably, on the whole, the poorer part, is sold in London. Many estates sell their better grades in Batavia and Amsterdam. The table below shows the average prices for the 1926 crop obtained in the London sales.

		s. d.
North India	...	1/5.68
South India	...	1/5.62
Ceylon	...	1/8.09
Sumatra	...	1/4.56
Java	...	1/0.83
Nyassa	...	1/1.24

The individual districts in North-East India for the same season made the following averages :—

		s. d.
Assam	...	1/6.38
Darjeeling	...	1/9.24
Dooars	...	1/4.38
Cachar and Sylhet	...	1/2.54

The London prices flatter somewhat the quality of Indian tea as a whole for, generally speaking, the better teas are sold at Home, and a great proportion of the poorer teas are sold in Calcutta.

However, making allowances for these facts, Java teas are undoubtedly inferior to Indian teas, although not to the degree shown by the London values. Many reasons for this inferiority have been given. One is the fact that there are about 60,000 acres of *kampong* (Malay, village) and native tea plantations. These areas are generally put out without a factory and the leaf is sold to gardens with factories. *Kampong-blad* (village leaf) is bought, usually, when the market is strong. *Kampong* tea is generally poorly cultivated and roughly plucked, although some of it, contiguous with European-owned estates, is very good, well-tended tea. The price paid for *kampong-blad* varies and and may be as much as 10 cents per ½ kilo (Rs. 9 per maund).

Another factor tending to lower the average price of Java tea is the sale of a rough grade, known as Bohea. This is only a small proportion, less than 5 per cent. perhaps, but it brings a very small price and lowers the average.

It is estimated that about 61½ million pounds of tea are consumed annually in Java. Garden labourers drink mostly Bohea. Of the tea exported, about 95 per cent. is shipped from Priok, the port of Batavia. The tea is exported mainly to Great Britain, Australia, Holland and the United States. Below is shown the distribution in 1925 of both Java and Sumatra teas.

	Java tea.	Sumatra tea.
Great Britain ...	39,475,000 lbs.	4,745,000 lbs.
Australia	32,968,000 ,,	3,067,000 ,,
Holland ...	19,650,000 ,,	5,381,000 ,,
United States ...	6,187,000 ,,	1,054,000 ,,

In 1905 it was decided to make a determined effort to improve the quality of Java tea and to this end a committee of leading planters, directors of planting companies and others interested in the tea industry suggested the formation of a Tea Expert Bureau. In 1906 an Englishman was employed to help the planters to make the best of their tea. The expert had an office first at Soekaboemi and, later, at Bandeong from which towns he reported on tea samples and visited gardens. There is no tea market in Batavia comparable with those in London, Calcutta or Columbo, but European buying firms have established themselves there and buy much tea by private contract. However, owing to the sellers having insufficient knowledge of the commodity and being out of touch with European markets, these contracts were not always, in the past, to the best advantage of the producer. Accordingly, in 1910 the Vereeniging "Thee-Expert-Bureau" took on its present form and moved to Batávia. The expert is British.

Only Dutch firms belong to the Bureau, for British agencies have their own tea tasters. At present 165 estates in Java and Sumatra are served by the Bureau, these including Arab and Chinese owned concerns.

Most of the Java tea is sold forward on the f. a. q. basis and it is the duty of the expert to see that the quality keeps up to the mark and to report any change of grade or shortcoming in the tea. In case of a dispute, the expert can act as arbitrator with two others.

The Bureau costs 60 to 70,000 guilders (£5,000 to £5,833) per annum, this sum being raised partly by a contribution of 10 cents (2*d.*) per 100 kilos (220 lbs.) of tea made, of a charge of 25 cents (5*d.*) per sample tasted, and of an annual charge of 50 guilders (£4-3-4) for circulars on prices, reviews, etc. From the sum raised, £1,000 is set aside for propaganda, which is used in advertising in American papers and journals.

The tea gardens of Java are run by agency houses much in the manner as in India. The managers and assistants on the estates are practically all Dutch. The salaries paid to tea planters are about the same as in North-East India, but Home leave is given less frequently. Commissions are higher than those usually given in North-East India.

The labour on Java tea estates is obtained locally, although in Sumatra it is recruited, on contract, from Java. In Java there is somewhat under one cooly an acre on the estate, but this figure varies widely. The labour is paid a rather higher wage than in North-East India, although the difference in cost of living may or may not account for this apparent extra remuneration. The cooly lines are well built and, on the whole, the standard of living is much higher in Java than in India.

The Tea Experimental Station.

The earliest scientific work on the subject of tea in Java was done by van Romburgh, Lohmann and Nanninga from the early 'nineties onwards, contemporaneously with that of M. Kelway Bamber in Assam and Ceylon. This work was carried out in the laboratories at Buitenzorg, connected with the famous Botanical Gardens.

In 1902 the Theeproefstation (Tea Experimental Station) was founded, with Nanninga as the first Director. In 1907,

Dr. Bernard, formerly of the Botanical Gardens, took over the Directorship and he still holds this post. The present staff consists, in addition to the Director, of two chemists, one botanist, one mycologist, one entomologist and three agriculturists.

The annual cost of the Tea Station is about 1,50,000 guilders (£12,500). A fine new stone building consisting of laboratories, offices, library, etc., comprising about 25 rooms, large and small, has just been erected some distance from the old laboratories at a cost of about 1,50,000 guilders.

In 1926 several associations were amalgamated and a central association consisting of a General Agricultural Syndicate for rubber, tea, coffee, cocoa and cinchona was formed. The money for scientific work will be raised by a cess of 2 guilders 20 cts. per hectare (about Re. 1-2 per acre). Under the previous system the money for the Tea Experimental Station was raised by a cess of about 20 cents (9 annas) per 100 kilos (220 lbs.) of tea produced. The cost of the Scientific Department at Tocklai works out at less than 8 annas per acre, owing to the fact that the annual expenditure, which is at present about £18,000, is borne by a much larger industry in India than in the Dutch Indies.

There was no tea for experimental purposes on the old Theeproefstation, but experiments were made on Pasir Soerronge, a garden some miles away. At the new station about 8 acres will be planted with tea and the nurseries are already put out (April, 1926). It is expected to have a larger area for planting eventually. At Buitenzorg, about 30 acres of land are devoted to green crops. This area is very fine and is managed by the Theeproefstation, although in 1928 it reverts to the Government Agricultural Department. There are many isolated areas in the jungle mostly at Tjinjiroean, on the Pengalengan Plateau, devoted to the work on tea selection.

The Theeproefstation published a quarterly journal, " De Thee "—which reached its seventh year, and also " Mededeeling-

en" or Reports on subjects concerning tea, as occasion arose. Between 1909 and the present, over eighty of these reports had been issued. Previous to 1907 the work on tea appeared in the journals of the Botanical Garden at Buitenzorg and in the Agricultural Reports. The scientists at the Theeproefstation publish many of their purely scientific works in European journals.

Since the formation of the General Agricultural Syndicate in 1926, mentioned above, the two series, "De Thee" and the "Mededeelingen van het Thee-proefstation," will be published in the "Archief voor de Thee-Culture."

TEA SELECTION.

The work on tea selection was first started in Java in 1910 by Dr. Ch. Bernard, Director of the Experimental Station, in a small garden set up at the Government Cinchona plantation. Other gardens were put out in the jungle on the Pengalengen Plateau and, as the work of type selecting grew, Dr. C. S. Cohen Stuart took over in 1913, and began to study the principles of tea selection and problems connected with propagation.

The peculiar interest in tea varieties which we have in Assam must be an excuse for the somewhat lengthy discussion on selection which follows.

When the East India Company decided to bring tea from China in order to grow it in India, and whilst C. G. Gordon was actually on his way from China in 1834, the report came through that tea had been discovered growing wild in Assam. Bruce had originally, in 1923, found tea near Sibsagar.

The first plants from China was put out at Kumaon and Dehra Dun, but since tea had been found indigenous in Assam, China plants were also out in that province. The commission of botanists consisting of Wallich, Griffith and McClelland which was sent to Assam in 1835-36 found tea growing wild in many places including Kutchu, Negrigram, Nadua, Tingri, Gabru-Purbat and Borhat, besides in the hills between Assam and Burma and at Bhamo on the Irrawaddy. It was concluded how-

ever that the Assam tea was a cultural variety of the China bush, which had reverted by growing in a wild state. The importation of China tea was therefore not considered harmful to the indigenous plant but was, indeed, considered desirable. This erroneous conclusion did much to introduce confusion into the tea strains of Assam which makes selection at present so very difficult.

When Cohen Stuart came to the problem, one of the aspects considered was that of the probable original home of the tea plant (1). A hypothesis has been put forward that, since the original tea areas are situated along several large rivers, the Yang-tse-Kiang, the Hsi-Kiang, the Song-Koi or Red River, the Mekong, the Salween, the Irrawaddy and the Brahmaputra, and since these rivers or their tributaries spring from the complex mountain system, conveniently termed the Ant i-Tibetan range, to the east of Tibet, these mountains represent the original distribution centre of the tea plant and it allies. This hypothesis is refuted by Cohen Stuart and it is suggested that the China plant arose independently of the large leaved varieties and developed amidst the other *Camellias* and *Theas* growing in China, to which it shows a much closer resemblance than to western tea forms. China proper has a flora which is much more its own than is the widely distributed flora of Indo-China, Burma and Assam. Thus there is a large leaved India tea plant in Manipur and a large leaved China tea in Yunnan but no large leaved tea plant in China proper.

Having decided that the large leaved varieties of tea may have spread from the Ante-Tibetan range, Cohen Stuart goes on to study the transportation of the tea plant by man. Tea plants have been found near the important caravan roads between China and India. The transportation and hybridisation was generally east in Sy-Chuan, south in Yunnan and west in Burma. The

(1) "A Basis for Tea Selection" by C. S. Cohen Stuart, *Bulletin du Jardin Botanique de Buitenzorg*, Vol. I, fasc. 4, written in English, contains a full accountt of the botanical aspect of tea selection and a discussion on the geographical distribution of the tea plant.

typical Chinese plant has suffered less blending than the other varieties and has remained comparatively true-bred. The tea in the Shan States of Burma and Siam is the most hybridised. Assam indigenous tea has also been subject to changes from without. On the other hand it seems that Manipur, Cachar and Lushai tea, which differ so much from the other large leaved varieties, has been preserved from the taint arising from migration.

The confusion regarding the systematic botany of tea has been largely cleared up by Cohen Stuart. Linnaeus in his Species Plantarum (1753) formed two genera, *Camellia* and *Thea* and, at that time, two species of Camellia, *viz.*, *japonica* and *sasanqua*, were known, and one of *Thea*, *viz.*, *sinensis*, the tea plant. In 1762 the two varieties *Thea viridis*, the plant giving rise to green tea, and *Thea bohea*, that giving rise to black tea, were distinguished and the term *sinensis* was dropped. Later it was shown that both green and black tea were made from the same plant, which was then called *Thea bohea*. Confusion started from this time and increased as each botanist worked on the problem. Sir George Watt, the most notable botanist in connection with tea during the latter part of the nineteenth century, distinguished two varieties proper, *viz.*, *viridis* Watt (large leaved) and *lasiocalyx* Watt (small leaved). From these two, other varieties, *stricta*, *bohea* and Ceylon hybrid were considered to be derived by hybridization.

Later botanists have decided that two separate genera for *Camellia* and *Thea* species are no longer necessary and the combined genus is known as *Thea* since this name was the first mentioned by Linnaeus. Only one tea species, *Thea sinensis* (L.) Seem, is now recognised. The designation is somewhat unfortunate from the geographical viewpoint since it suggests China tea.

There exists, however, at least two morphological groups of tea plants, one of which is indigenous to China, the other to India, whilst there is, according to Cohen Stuart, not the small-

est evidence supporting the idea of any direct genetical or genealogical affinity connecting them.

To a great extent it is a question of convenience whether we speak of species of varieties, and the question ought not to be invested with undue importance. Within the species Cohen Stuart recognises four main groups.

Group I, China, variety *bohea*. Small leaves, 1½—2½ inches long, leaf stiff, leathery, usually deeply coloured with 6 to 8 pairs of veins which are not very prominent; leaves usually without a definite apex. This group occurs in East and South-East China and Japan.

Group II, variety *macrophylla* v. Siebold. Large leaves, up to 5½ inches long. Trees up to 16 feet high. Number of veins about 8 or 9; no leaf apex. Occurs in Hupeh, Sy-chuan and Yunnan.

Group III, Shan form, perhaps related to "Assam" tea. Large leaf, up to 6½ inches long. Trees 15-30 feet high. Leaf light coloured with about 10 pairs of veins and continuous apex. Occurs in Tongking, Laos, Upper Siam, Upper Burma (collectively known as 'Shan' lands), possibly also Assam.

Group IV, variety *assamica*. Very large leaves, 8-12 inches and even up to 14 inches in length. Trees up to 60 feet high. Leaves comparatively thin and flaccid, moderately dark green, with 12 to 15 pairs of veins, which are very prominent and result in the striking wrinkling of the leaf surface; moderately long, sharply defined apex. Occurs in Manipur, Cachar, Lushai (2).

Cohen Stuart has shown that tea is cross-fertilized and that flowers only self-fertilise with difficulty. The significance of this is that the seed from any bush may give a hybrid plant, unless care is taken to ensure that the pollen from bushes of the

(2) Tee, Camellia theifera (Griff.) Dyer, by Cohen Stuart, *Fruwirth Handbuch der landw. pflanzenzichtung.*

same variety only is available for cross-pollenization. A wasp has been noticed carrying the pollen in Java.

The need for putting seed gardens in isolated places thus becomes apparent, and the need for keeping our varieties pure is obvious. Cohen Stuart writing on tea in India says (3), "Carelessness about the variety of tea planted, carelessness about the precious wild tea tracts, carelessness about the management of seed gardens, carelessness, in short, about all measures that are liable to ensure an effective tea selection, such, I regret to say, has been the happy-go-lucky attitude of the British planters towards a matter that could not indeed, yield immediate profits, but should undoubtedly have done so at one time or another. Nor did they lack good counsel, for Sir George Watt has, ever since 1882, endeavoured to reorganise the Assam seed gardens."

How far the rebuke is merited it is difficult to say for, on Cohen Stuart's own statement, there has been hybridization in the Assam seed tracts for some time. We know too that Burma tea seed, brought from thick jungle, far removed for any modern cultivation, gives plants of widely different characteristics. It is thus probable that hybridization had been going on long before the planter came to Assam.

From the seeds of commercial jats as used in Assam and exported to other tea countries, the botanists in Java set about selecting pure strains. With this object, 22 areas in the jungle at Tjinjiroean, on the Pengalengan Plateau, each isolated from the others by a walk of at least ten minutes, were selected as sites for seed gardens. The altitude of these areas varies from 5,000 to 6,000 feet and some areas are at 6,500 feet. Each seed garden occupies an area from about 1½ to 2½ bouws (2.6 to 4.4 acres). Of the 22 areas, 19 were put out from jats imported from India and three from Java grown seed. The Indian seed includes the commercial varieties or jats known as Ghoirali (two areas), Rajghur, sometimes called Dr. Watt's variety (two

(3) "A Basis for Tea Selection," p. 206.

areas), Ghairkhatta, Mitanguri, Singlo Hill (two areas), Jaipur, Bazaloni, Itakhuli, Nakhati, Manipuri, Kalline, Alyne, Dhonjan, Kutchu, Goipani and a pseudo Itakhuli, from Itakhuli stocks with Ghoirali scions. The Java seed includes Tjiliwong, Malabar and Kiara Pajoeng.

The nurseries were planted out 15 cms. (6 ins.) square. At two years the plants were carefully selected for jat, regularity of branching, height, freedom from diseases like Brown blight and Pink disease, and were then replanted six feet apart. Four years after replanting, *i.e.*, six years from seed, a second selection was made according to jat, freedom from Corticium and root diseases. In the seventh year from seed, a third selection was made and in the eighth year still another.

By this method of stringent selection, only 250 trees were left in the 22 gardens, and these were used as parent trees in the grafting work which followed. As planting was begun in 1914, the parent trees are now 14 years old. The Ghoirali clearance showed the most parent trees with 40, and Rajghur came second with 28.

The value of the vegetative propagation of tea will be appreciated, although the possibilities are not so great as with some other crops. By means of grafts or bud grafts, a seed garden of uniform type may be obtained. In addition, by grafting, it is possible to obtain an absolutely uniform material for pruning, plucking or similar experiments (4).

The conversion of inferior bushes to high yielding ones has not been shown possible yet and, in any case, might not be practicable over large areas. Yet the possibility of extensive grafting is shown by the fact that Cinchona trees in Java are usually grafts from the stock of *Cinchona succirubra* and the scion of another species, *C. Ledgeriana*. The bark of the latter contains 7 to 10 per cent. quinine whilst that of the former only

(4) Vegetative Propagation of Tea by A. A. M. N. Keuchenius.
Translated and summarized from *Mededeelingen van het Proefstation vor Thee*, No. 84.

contains 1 to 3 per cent. although the root of this species, used as the stock, develops quickly and well.

Before attempting to propagate tea vegetatively it was necessary to establish a method. In the tea seed gardens at Tjinjiroean many methods were put to the test, *viz.*, crown, cleft and splice grafting, layering, inarch and upright stem layering, and various kinds of budding and veneering. The results showed that crown grafting, budding and upright stem layering were the best, and a brief reference to each of these three methods may here be made.

Crown Grafting. The crown grafting is best made on a six or seven-year old stock, which is sawn off some inches from the ground and allowed to grow three or four strong shoots. After eighteen months or two years these shoots, which should not be less than 4 to 6 cms. (1.6 to 2.4 ins.) diameter 15 cms. (6 inches) above the stump, should be cut off squarely at the latter height. After an interval of one to three days, when the excessive bleeding has ceased, the grafting is done. Young plants, two years old in the nursery, may also be grafted by inserting the scion on the stem itself instead of on a two-year old shoot from the stubbed stem, as in other cases. Direct grafting in this manner is however less successful than the other.

The scion used in crown grafting must be a vigorous young shoot, the best ones being obtained from 7 to 12-year old trees, which, during the rainy season may yield as many as 50 to 150 scions per month. The best scions are the top shoots of the main stems. These young shoots are cut 20 to 25 cms. (8 to 10 ins.) long and the leaves cut back to 2 cms. (¾ in.) leaving the buds in the axils. They should be grafted as soon as possible, but if kept in a damp place, wrapped in moss or ferns they may be kept for two days.

The part of the shoot between the fourth and eighth leaf counting from the tip, is made use of for cutting scions.

The stage of development of the buds of the scion is of great importance. They should be at that stage when their tegment leaflets are standing quite apart whilst the top of the young

bud should be clearly visible between the expanding bracts. The accompanying plate, reproduced from the Report on Vegetative Propagation of Tea, by Keuchenius, illustrates this point.

Before fixing the graft, the top of the sawn stock is made smooth with a pruning knife. At the top of the stump a smooth portion of the bark, without dormant buds, is chosen for inserting the graft. The graft is bound to the stock by very thin strips of damp bamboo, and the mounted graft is carefully covered with wax consisting of—

Resin	...	... 10 parts
Suet	...	... 2 ,,
Paraffin wax		... 1 part

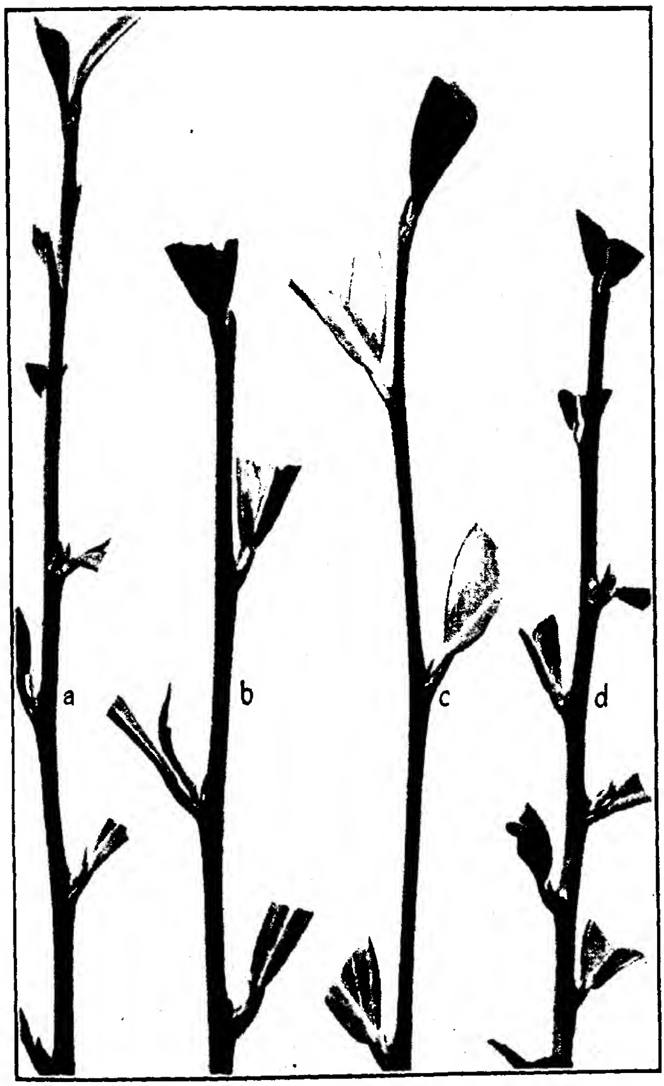
After grafting, young shoots growing from the stock must be cut away every few weeks for the first few months. The grafts should be shaded.

Budding. Budding may be done on the main stems of two to four-year old plants in nurseries or seed gardens, on the lower side branches of stumped trees or on two to four-year old shoots of stumped trees. Budding should be carried out as low as possible on the stem or branch which must be kept free from side growth for a certain distance during the year before budding.

The buds should be taken from branches four to eight inches in circumference with a good number of dormant buds. The bark of the budding wood should not be thin, and should be at least as thick as that of the stock. Only dormant buds should be made use of.

The buds are cut and grafted quickly andd accurately and then bound with calico and waxed.

Upright Stem Layering. With upright stem layering, the best results have been obtained with two year-old shoots of stumped or pruned trees. The branch to be layered is ringed and the bare cambium (growing layer of the stem) destroyed by gentle rubbing with the back of a knife. A split bamboo filled with leaf mould is placed round the cut. After about nine



Tea scions.

a. suitable buds ; *b.* buds too much developed ; *c.* stem too thin, with buds too far apart and insufficiently developed ; *d.* very fine scion with stout stem, buds in fair stage of development and near one another.

months the layering should have rooted and can then be severed from the parent tree and topped for planting out. Shading is necessary for a year after transplanting.

It was found that the best success with grafting was obtained from the Ghoirali, Kalline and Rajghur jats. Bazaloni was difficult to graft because of the thin cambium.

The seed gardens at Tjinjiroean as they now stand, consist of magnificent trees of a regularity and fineness never seen in our seed gardens in North-East India.

Yet, interesting and important as is the work of vegetative propagation, it has been noticed, by careful experiment, that there is practically no correlation between jat and crop and that Assam or Burma bushes with small leaves, usually assumed to be poor jat, may yield better than many of those of a purer jat. Accordingly, another selection scheme is now being worked out in which scions are taken from high-yielding bushes. For this purpose graftings have been made at an estate called Pondok Gedeh from good, medium and poor bushes on to stocks in alternate third rows. Any influence due to soil is thus accounted for if enough series of rows are taken. The crops will be collected from the various rows and correlation, if any, observed between the yield of the original bush and graftings derived from scions of that bush.

THE CLIMATE OF JAVA.

The general features of the Java climate are abundant rainfall, feeble winds, high temperatures and high humidities, all factors going to make an ideal tea climate.

The Monsoon as we know it in North-East India does not occur in Java. The tea areas in North-East India back up to the Central Asiatic Plateau and, in this position, receive either the hot, moisture-laden winds from the Indian Ocean, constituting the south-west Monsoon, or the gentle spill-over of cool, dry air from the Tibetan Plateau, as it flows during the winter to the warm areas near the Equator. Although Java is subject to a change of wind as the thermal Equator moves north from

April onwards and another change from November on, as the Australian continent warms up, the breeze at all times of the year is a moist one, and the seasons are only marked by an increase or decrease in rainfall, and not by an entirely new set of conditions as is the case in North-East India.

The wind strength in Java is not great, and even when the Monsoon is most steady, the direction is not constant.

In Java the sun usually rises in a clear sky, or perhaps a few stratus clouds, little more than a rising morning mist, appear in the sky. About nine o'clock small cumulus clouds appear and these increase till rain comes in the afternoon or the clouds abate and a calm tropical night follows. Such days often occur in Assam during late April and in May.

The table below shows the rainfall at Buitenzorg, 885 feet above sea level, at Soekaboemi, the centre of the tea area, situated at an altitude of 1,968 feet and at Malabar on the Pengalengan plateau, about 5,000 feet up. For purposes of comparison, the rainfall at Kandy, one of the tea centres of Ceylon, and at Tocklai which is representative of the Assam Valley, together with that of Siantar, the centre of the largest tea area in Sumatra are also given.

	Buitenzorg.	Soekaboemi.	Pengalengan Plateau.	Siantar, Sumatra.	Kandy, Ceylon.	Tocklai, Assam.
Elevation	885 ft.	1,968 ft.	5,000 ft.	1,500 ft.	1,654 ft.	290 ft.
	ins.	ins.	ins.	ins.	ins.	ins.
January ...	17·6	24·7	13·9	11.1	5·2	1·0
February ...	15·9	11·2	12·5	7·2	2·2	1.4
March ...	16·6	15·1	13·2	8·9	3·9	3·6
April ...	16·2	16·1	10·9	8·7	6·8	7·9
May ...	14·9	10·4	6·6	12·0	5·4	9·7
June ...	11·1	6·5	4·4	6·7	9·6	12·4
July ...	10·2	3·9	2·4	6·7	7·5	17·0
August ...	8·8	3·8	2·6	9·6	5·7	13·0
September ...	13·5	4·0	4·2	13·7	5·9	10·1
October ...	16·7	9·1	7·7	16·7	11.8	4·5
November ...	15·6	13·8	10·7	8·8	10·6	0·9
December ...	14·6	16·4	13·3	9·8	9·1	0·4
TOTAL ...	171·7	135·0	102·4	119·6	83·8	81·8

Conditions at Tocklai are indicative of those in Northern India where the rainfall shows a regular increase and decrease with the advance and retreat of the south-west Monsoon. At Kandy, the advance of the south-west Monsoon is apparent somewhat earlier than in the Northern India. The heavy rainfall in October, November and December is brought by the north-east Monsoon which, having blown dry from Central Asia, has picked up moisture crossing the Bay of Bengal and is thus able to deposit rain on the eastern side of Ceylon. Kandy in its central position receives copious rain from both Monsoons. Conditions in Sumatra are somewhat similar to those in Ceylon.

In spite of the fact that Java, like Ceylon and Sumatra, is surrounded by sea, it actually gets only one wet season over the greater part of the island, although the dry season is only dry by comparison.

Most of the rain comes from a north-westerly direction for the west or wet Monsoon has travelled farther over the sea than the east or dry Monsoon. Also, during the wet Monsoon, the vertical factor in the air movement is an ascending one and the opposite of the east Monsoon (descending), both factors tending to accentuate the particular characteristic of the season.

In the east of Java, droughts may be severe and this is one of the factors accounting for the fact that tea is practically confined to west Java.

In North-East India, with a five-month drought period, it would appear at first sight that conditions were much harder than in Java. Conditions are, however, not comparable, for temperatures are much lower in India during the dry period than in Java where, as in Ceylon and Sumatra, a steady high average is maintained through the year, with a correspondingly rapid rate of evaporation.

The mean temperatures in January and July in Java and other tea countries are shown below.

	January °F.	July °F.
Buitenzorg	75	77
Bandeong	72	72
Pengalengan	62	62
Siantar (Sumatra) ...	71	73
Kandy (Ceylon) ...	73	75
Nuwara Eliya (Ceylon) ...	57	59
Tocklai (Assam) ...	60	83

Frosts occur on the Pengalengan plateau and, in the lowest basins of this undulating area, damage is done to tea when the temperature falls below 30°F. Frost is registered in July, August, September and October.

Although the crop is gathered in Java all the year round, it is not distributed evenly through the year. The heavy cropping period begins in November and continues till April, coinciding with the wet season. During the drier part of the year less crop is made.

Meteorological observations are taken very fully on Java estates where, in addition to the simpler instruments like thermometers and rain gauges, sunshine recorders and self-recording hygrometers and thermometers are also used. Some estates have anemometers installed. The observations are sent to the Meteorological Station in Batavia with the result that a very complete and comprehensive mass of data is available.

The Tea Soils of Java.

The soils of the greater part of Java consist of the weathered products of eruptive rocks, and most of the tea soils are derived from the weathering *in situ* of volcanic ash, sand and lava.

The oldest rocks, granites and shales, which make up the foundation of the island, are very little seen on the surface because they were covered up during the tertiary period with vol-

canic material. The formations of the cretaceous period are also unimportant with regard to the present state of the island. The volcanic deposits of the tertiary and later periods form the greater part of the present surface. During later geological times, the eocene and miocene periods, sandstones, conglomerates and breccias of volcanic material were formed. In the later miocene period clay, marls and limestones were formed.

Andesite and basalt, give rise to about 75 per cent. of the soils in Java, the older eruptive rocks giving rise to soils are diabase and gabbro. These are all volcanic rocks of the basic type, by virtue of the fact that they contain not more than 60 per cent. silicic acid and the balance of basic oxides of lime, magnesia, soda, iron and alumina.

These basic rocks differ from the acid rocks composing a large part of the Himalayas in that they are richer in substances giving rise to plant foods. The Himalayan rocks give rise to the Darjeeling and Dooars soils. Most of the Assam tea soils are new alluvia, consisting of as much as 90 per cent., in some cases, of insoluble matter, mainly quartz.

In order to compare the Java soils with those of North-East India, some suitable method of classification is necessary. Such a classification is admittedly difficult. Thus a classification based on geological origin will not serve in regions where the climate differs widely, for the same rock may give rise to totally different soils according to climate and the degree to which the disintegrating processes have proceeded.

Classification on a purely physical basis is scarcely more satisfactory since, as such, it may involve the grouping together of soils otherwise absolutely unrelated. Such a classification is however of practical importance and will be dealt with later.

The broadest classification is related to the mode of operation of rock disintegration and rests ultimately on a climatological basis, since the process of rock degradation is controlled by

climatic factors. The original material may differ, but the constant working of a given set of conditions tends to produce the same product. On this climatic basis, the soils of Java are classed as lateritic (5).

The process of laterisation is not completely understood but it depends on the leaching out, by alkaline waters, of the silicic acid from the weathering complex. The most favourable conditions for this occur in the humid tropics and, in extreme cases, the surface soil consists almost entirely of hydrated iron and aluminium oxides.

In Java where the temperature changes according to the altitude and the rainfall varies widely, different stages of laterisation are seen. Thus on the hot, sunny lowlands where the rainfall is so persistent that the general water movement is down through the soil, typical red laterite is formed. In the higher altitudes where temperatures are lower, the sky often cloudy and the bacterial activity of the soil accordingly slowed up, somewhat less well developed types of laterite occur.

In the high mountains of Java there is a layer of white decomposing rock under the humus soil. This layer is bleached by the humic acids as they are washed down from the upper layers, carrying with them the salts of iron and alumina to lower layers. This is the reverse process of laterisation and is similar to the disintegrating processes noticed going on in some parts of the hills bordering the Assam Valley.

In other parts of Java where conditions of intensive percolation of water through, and evaporation of water from, the soil occur alternately according to the seasonal rainfall, black and brownish soils occur. These conditions correspond generally with ours in North-East India where the process of turning brown is hastened by aeration. The general tendency in our soils is

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(5) This side of the subject is fully developed by G. D. Hope—"Some Aspects of the Tea Industry in Java," I. T. A. publication, 1914.

towards laterisation, although the rate of change is much slower than in Java.

One point worthy of note is that lateritic clays are not sticky as are ordinary clays in which the fine particles are composed not of the hydrated oxides of iron and alumina, but of complexes of alumina and silica.

Leaving now the geology and classification of Java soils it is of interest to examine them from the practical point of view and to compare them, with regard to their content of plant food, with the tea soils in North-East India. The Dooars soils are comparable in richness to those in Java, but the average Assam soil is much poorer.

The best Java soils contain 1 per cent. nitrogen and the average about 0.35 per cent. The average in North-East India is about 0.1 per cent. and the best soils of the Red Bank in the Dooars may contain as much as 0.2 per cent. nitrogen. The nitrogen in the alkali soluble humus or *matière noire*, in Java is about the same, or somewhat greater, than the total nitrogen in Assam. With a nitrogen content as great as is shown in Java soils we should rarely, in India, advise the use of nitrogenous manures.

On the Pengalengan Plateau the soils show an average content of organic matter of about 10 per cent., with an average alkali soluble humus content of about 3 per cent. These values compare with the best of the Red Bank soils in the Dooars. The best Java soils show about 50 per cent. of the organic matter as *matière noire*.

The potash content of the Java soils is very high, so high that it is not a factor to be considered, and the application of potash manures has been found to give no beneficial results.

The phosphoric acid is considered poor in the tea areas in west Java, although a wide variation occurs and, on this account, an average value is robbed of its significance. In the

tea soils of North-East India the average total phosphoric acid varies from about 0.05 to 0.15 per cent. and the available is about 0.01 per cent. or less. The values in Java are generally smaller than these.

The total lime also shows a wide variation in Java as in India and may be as little as 0.1 per cent. or as great as 1 per cent. on different soils. The average value for total lime in Assam is about 0.1 per cent. and on the Red Bank in the Dooars about 0.4 per cent.

The Java tea soils are slightly acid. A soil with a pH value of 6.8 grows good tea but the bushes on such a soil are subject to the root disease, *Rosellinia arcuata*. Many Java soils show pH values circa. 5.5. The pH values of the tea soils in India vary considerably, but 5.5 is a fair average. Soils showing values of about 6 or above are generally bad for tea in North-East India.

The mechanical analyses of the Java tea soils show them to vary over an extremely wide range from the lightest of sands to very heavy clays. The very young volcanic soils are very sandy and, as a rule, contain only a small percentage of clay. The young volcanic soils have had time to weather and may be classed as fine sands or as silts, although many of them are as light as the very young volcanic soils. As the age of the soil increases, the percentage of the finer soil particles increases and the older soils, which have come from the younger ones, show clay fractions often as great as 60 or 70 per cent. The geologically old soils contain still more clay than this last type.

The Pengalengan soils resemble physically some of the volcanic soils and are silt types. The striking characteristic of these soils is their richness in organic matter.

In North-East India where soils have been partly laid down by water and partly weathered, the variation in soil types is much greater than in Java.

The table below shows the various soil types in Java with the fractions given after Mohr's method of mechanical analysis (6).

Soil Type	Sand %.				Silt %.					Clay %.
	Very coarse.	Coarse.	Medium.	Fine.	Very fine.	Sandy.	Coarse.	Medium.	Fine.	
Very young volcanic	47	24	15	1	1	2	2	3	2	2
Young volcanic ...	7	9	23	22	9	11	8	6	3	2
Pengalengan ...	2	4	20	24	15	16	8	5	2	4
Old soils ...	0	0	1	2	1	3	4	12	10	63

These values cannot be exactly converted into figures comparable with analyses made on North-East India tea soils by Hall's method. A rough comparison however may be made from the following table in which the values from the first table are indicated, as nearly as possible, according to Hall's limits for the various fractions. The figures denote percentages.

Soil Type.	Gravel.	Coarse sand.	Fine sand.	Silt	Fine silt.	Clay.
Very young volcanic....	47	37	2	2	3	4
Young volcanic ...	7	32	31	11	14	5
Pengalengan ...	2	24	39	16	13	6
Old soils ...	nil	1	3	3	16	73

First, it is necessary to remark that very few of the North-East India tea soils, except in the Dooars and on the North Bank in Assam, contain gravel. The very young and young volcanic soils resemble the Mal sands of the Dooars mechanically. The Pengalengan soils are similar to the sandy silts of the Eastern Dooars, the North Bank of Assam and to some of the soils on the Doom Dooma bank. We have no soils under tea approaching the old soils of Java in heaviness. Some of our heaviest soils

(6) Over de Theegroden van Java en Sumatra J. J. B. Deuss, *Mededeelingen van het Proefstation voor Thee*, No. 89.

occur in the Sibsagar district of Assam, and contain as much as 50 per cent. clay, of a yellow colour and sticky nature.

Planting, Pruning and Plucking.

About three quarters of the tea in Java is situated on slopes and steep hills and most of the tea is planted at altitudes above 1,000 feet. On account of the irregularity of the land and because of the type of plucking, the extensive, even sheets of tea which are a feature of North-East India are not seen. The Java tea areas resemble in appearance, those of Ceylon and South India.

The tea plant in Java seeds all the year round, but most freely in November, December and January, and gives a total seed crop about the same as in India. Most of the planting is done between the beginning of the rains and the end of February and the seed not used locally is exported to Sumatra and Ceylon.

The seeds are planted about six inches apart in nurseries and overhead shading, supported by bamboos, is advocated. At about 14 months the young plant is cut to about six inches, the soil loosened and the "stump" removed and replanted in a manner similar to that employed in Ceylon and South India. Seed is often sown at stake, shaded with Boga medeloa (*Tephrosia candida*) planted in rows to help the formation of terraces. Transplanting with a clod is seldom practised.

Tea used to be planted in rows with the bushes three feet apart, triangular to the bushes in the next row planted at a perpendicular distance of four feet from the first. It is now suggested that the rows shall be six feet apart in order to leave a space from green cropping.

In Sumatra, where opening out is at present carried on all the year round, several methods of transplanting are employed. Seed is planted at stake and, by this method 50-60 per cent. of the plants live and thrive. Two-month old plants are also used and are transplanted without earth. At this stage the seedling is still living on the cotyledons, and the shock of transplanting

is not serious. From 80-90 per cent. of such plants are successful but the drawback to this method is that selection is difficult. With somewhat older plants, "stump" planting gives 70 per cent. successes, whilst clod planting with still older plants gives 90 per cent. successes.

The pruning of tea in Java differs essentially from that in North-East India and resembles that practised in Ceylon and South India. Indeed there is a close resemblance between methods throughout the treatment of the bush and the manufacture of tea in these three areas, owing largely to similar climatic conditions.

Pruning in Java is not done so well nor so carefully as in Assam although it is usually better than that in the Dooars and the Surma Valley. When a "stump," cut at six inches in the nursery, has been transplanted about two years it is cut across at about 20 inches, a little lower in the centre than at the sides. In many cases this cutting is accompanied by centering. The bush is then pruned up, on an average every two years for the next ten years or so, *i.e.*, five times, after which it is taken down again to about 20 inches.

On some gardens a "skiff" is given to the bush in place of a light prune and, although this gives leaf temporarily, the ultimate result of such treatment is detrimental to the bush.

One of the most important factors to be considered when discussing pruning methods, is climate. Java has no dry, cold weather when the bushes stop flushing, and plucking continues steadily for two or three years before the bush is pruned. On account of the climate, old wood can be cut without much snag formation and the cuts heal over well, owing to the light plucking. It is unsafe to attempt to prune in North-East India on the lines adopted in these regions of continual rain and steady high humidity. Tea left unpruned in North-East India becomes diseased and looks very different at the end of two years from the healthy bushes seen in either Java or Ceylon. Even if our bushes were as lightly plucked as in these countries it is doubtful

whether, after the strain due to the drought, the bush would enter the second season so well equipped as a similar bush in Java. Apart from labour considerations, alternate year pruning does not pay in the plains districts of North-East India. On the healthiest of tea it is however occasionally profitable (once in three years, perhaps) to leave the bushes unpruned.

After ordinary pruning in Java, the bush is out of commission for three months more or less, according to the age of the wood cut. The first plucking is made above three leaves, the next above two leaves and then above one leaf for all successive pluckings. After heavy pruning, plucking is made at a height of about 28 inches.

By somewhat closer plucking than that described above and by plucking to the *janum* or " fish leaf " in the third year, the height of the bush can be kept down so that pruning can be put off for another year, although after such a period the plant takes longer to recover than if it had been pruned at the end of the second year.

Three leaves and a bud are plucked and smaller shoots than this are considered to be immature. The plucking period is 10 or 12 days and sometimes up to 16 days. With the leaving of a leaf at each plucking the bushes get steadily taller till at pruning time they may be seven feet high. With these high bushes the thin supple branches are bent over to be plucked.

Consistent plucking to the *janum* at a height of about 30 inches has been tried in Java but this brings on Red rust and Mosquito blight. Such close plucking in Ceylon also seriously harms the bush and, indeed, in North-East India, *janum* plucking on a six-inch growth with a top pruned bush can only be practised year after year on strong tea. Judging also by experience in our own districts it seems that coarse plucking to the *janum* is much harder on the bush than fine plucking consisting of two leaves and a bud, to the *janum*. In the Dooars and the Surma Valley where three leaves and a bud are generally taken, *janum* plucking is not practised until well on in the season.

Although the actual plucking is coarser in Java than in India, the plucking is so long, *i.e.*, always above a leaf, that the crop gathered is not as large as might be expected. On account of the high bushes and difficulty in moving amongst them, the leaf is collected in cloths and not in baskets.

Manuring and Cultivation.

The practice of using artificial fertilisers is increasing in Java, but has by no means reached the same stage as in India. Experiments show that nitrogenous and phosphatic manures improve the crop but potash does little in this respect. This corresponds with our experience of manuring red soils in North-East India and is the same as has been osberved in Ceylon. Although nitrogenous manures alone give a crop increase, they are best added with phosphatic manures.

Manures are applied at rates given as so much per bush, and the following suggestions are made by the Theeproefstation. Per bush, 10 gms. sulphate of ammonia, with or without superphosphate or 20-30 gms. urea or 75-100 gms. whale fish guano or 75-100 gms. animal meal. These manures are added every other year.

The amount of manure added by 30 gms. sulphate of ammonia per bush according to Java planting, where about 3,400 bushes go to the acre, works out to 220 lbs. per acre or an equivalent of about 45 lbs. of nitrogen. The double dose adds, of course, 90 lbs. nitrogen. These figures may be compared with the practice in North-East India of adding about 30 lbs. nitrogen each year.

The manures are broadcast with a hand fork, preferably a short time before the rains or after pruning. If chemicals are given one time, oilcake may be given the next. The general idea in manuring is first to get a good, humus-rich soil, producing a good bush, which is then manured, since it pays best to manure good tea. It is suggested that poor tea should be rested under *Albizzia moluccana* (Ceylon Sau) in order to strengthen it, in preference to being manured and plucked.

Cattle manure is not used to any extent and, indeed, in a country where an effort is made to control weed growth, the use of this manure introduces a serious difficulty, because it carries with it the seed of weeds.

Green manuring by means of ground crops and shade trees is widely practised in Java tea gardens, and it is common for the whole garden to be under a green crop of some kind. The older the garden and the closer the tea the more necessary is it to supply the organic matter from shade trees.

It has been observed that different green crops are able to tolerate different ranges of soil acidity and the continued application of sulphate of ammonia seriously affects the growth of some of the crops, since this manure tends to increase soil acidity.

Of shade trees grown, *Albizzia moluccana* is the best and most popular. The Dadap (*Erythrina indica*) and *Derris robusta* are also common. Shade trees are closely planted, pollarded at about 12 feet, and later on lopped and the loppings left as a mulch or buried. It is common to leave the shade up in the dry season and to lop it in the rains.

Of the ground green crops, *Tephrosia candida* (Boga medeloa), *Crotalaria usaramoensis*, *C. anagyroides*, *Indigofera endecaphylla*, *Calopogonium mucunoides*, *Vigna oligosperma*, *V. hosea* and *Leucaena glauca* are at present most used. The last which has deep roots, is much grown on hill slopes. *Clitoria cajanifolia*, once very popular, is not widely used now.

The method of using green crops in Java is quite different from that in North-East India on account of the different climate. In the latter country one of our problems in the dry months is the conservation of soil moisture and a clean soil, mulched by hoeing, is necessary to that end. In Java the green crop is left up as long as possible and then cut, and allowed to grow again. The cut crop is left on the soil as a mulch to keep off the sun.

Some years ago the tea estates in Java practised clean weeding, as is still the procedure in Ceylon. This process has now been stopped and either selective weeding is used, or the soil

is covered with a low growing crop if the bushes themselves are not big enough to keep the weeds in some sort of control.

At present the consensus of opinion is against frequent soil disturbance, much as is the trend of ideas in North-East India, although control of weeds is necessary. Deep cultivation in the form of deep hoeing and trenching has also ceased to be as necessary as it was when frequent light hoeing was the rule. Another reason why the amount of trenching is limited is that it leads to the spread of *Diplodia* and prunings are left in lines but not usually buried. *Diplodia* (known as *Thyridaria tarda* in North-East India) is controlled by the addition of lime to the trenches.

Drains are not as a rule necessary in Java because the soil is so porous. The loss of soil by wash is reduced in areas where the tea is small, by means of silt pits, although after weeds have been grown selectively this practice is not continued. Soil wash is also reduced by hedges of green crops.

The hill slopes on tea estates are perfectly terraced, for the natives themselves are masters of this practice in their own cultivation. Sometimes the hill side is contour planted with a green crop before planting, so that the terraces form naturally.

PESTS AND BLIGHTS.

Most of the fungi which attack tea in North-East India are konwn in Java, although they operate with different degrees of virulence.

Of the root diseases, *Ustulina zonata* (Charcoal stump rot) is common on all soils. *Rosellinia arcuata* (Black root rot) occurs on soils which are neutral or only faintly acid. *Fomes lamaoensis* (Brown root rot) occurs sometimes, but *Sphaerostilbe repens* (Violet root rot) does not attack tea, although it is common on rubber and green crops. *Diplodia* (Die back) also occurs.

So far as leaf and stem diseases are concerned, these blights are much less prevalent than in North-East India, where, at the

end of the season, the leaves and small shoots are often a mass of blights, especially if the plucking has been hard. In Java, Brown blight and Grey blight are common but Blister blight and Copper blight are not known. Thread blights, Nectria and Corticium are known, but are not common. Red rust is a very serious blight and often completely cripples weak or debilitated tea, especially after an attack of Mosquito blight.

Septobasidium rubiginosum is very serious and may kill out strong plants, both tea and green crops. *Septobasidium* spp. are found in North-East India, parasitic on scale insects but, so far, on only two occasions has the fungus been observed to be parasitic on the tea plant. The attack of *septobasidium* in Java has increased during the past few years and has spread from dadap and *Crotolaria anagyroides*. An attack by this fungus may be followed by Red rust.

The spraying of tea for blights is not practised in Java and the formation of the land is all against the carrying of materials for intensive spraying. For the most serious leaf and stem disease, *i.e.*, Red rust, the bush is given a rest from plucking. Generous treatment is regarded as the best safeguard against fungus attack.

The most serious tea pest in Java is *Helopeltis* (the tea mosquito). The Pink mite is sometimes serious but Red spider is not so common as in India. Thrips and other pests occur, but are not serious. Green fly is not known.

Much interesting and useful work has been done on mosquito blight in Java. The species of *Helopeltis* known in Java are *H. Antonii* Sign., *H. Theivora* Waterh., *H. Cuneatus* Dist. and *H. Cinchonae* Mann. *H. Theivora*, the species doing damage in North-East India, is practically harmless in Java where *H. Antonii* takes the greatest toll of the tea bush. At altitudes above 4,000 feet a different variety of *H. Antonii* is found which prefers Cinchona to tea. *H. Cinchonae* has been shown to attack tea.

According to observations it appears that the mosquito punctures the veins of the leaf and that immune bushes are harder in the veins than others.

The mosquito cannot stand exposure to bright sunlight while dense shade encourages the pest. However, since the foliage of the bush itself provides sufficient shade for the insect, the cutting down of shade trees has not been practised in Java. The removal of shade may, however, have an indirect influence on the mosquito, in that bushes growing in the sun have a somewhat different composition from those growing in the shade. It has been observed in Assam that the removal of shade trees does, at times, diminish the intensity of mosquito attack.

Many methods of combating mosquito have been tried, including hard plucking, special pruning, hand catching, fumigation and spraying, with varying results, generally failure.

A few years ago the entomologist at the Theeproefstation discovered a parasite of the tea mosquito, *Euphorus helopeltidis*. The eggs of the parasite are laid on the first larval stage of the mosquito and, later, the cocoon of the parasite goes to the soil. When the mosquito is hand caught, samples are sent to the Theeproefstation for examination and if more than 50 per cent. of those in the larval stage are infected with the parasite, it is advised that hand catching be stopped. By this means the reproduction of the parasite is encouraged. It has been observed that shade encourages the parasite. A parasite of *Euphorus helopeltidis* has also been discovered but it is rare. In North-East India a parasitic mermithid worm has also been observed but its ravages on the tea mosquito are not serious enough to warrant any hope that it may control the pest.

On Tjiboengoer Tea Estate interesting experiments on the control of mosquito by pruning have been made (7). Briefly, the treatment consists in pruning alternate rows of tea in a block

(7) A full description of this work together with a comprehensive account of the work on tea mosquito in Java is given by H. Ashplant in "Report on Mosquito Blight (Helopeltis) of Tea in Java."

every two years. Only good areas of sound tea, from which the worst effects of the blight have been eliminated by previous good treatment, may be expected to respond to alternate row pruning.

This type of pruning has been tried on other estates, sometimes with success and sometimes failure. The reason why bushes pruned in this manner should be able to throw off the blight has not been explained, but it may be due partly to the fact that the surroundings are rendered less favourable to the insect, and partly to the fact that the area as a whole benefits by having part of the bushes exposed every year to the sunlight at pruning time.

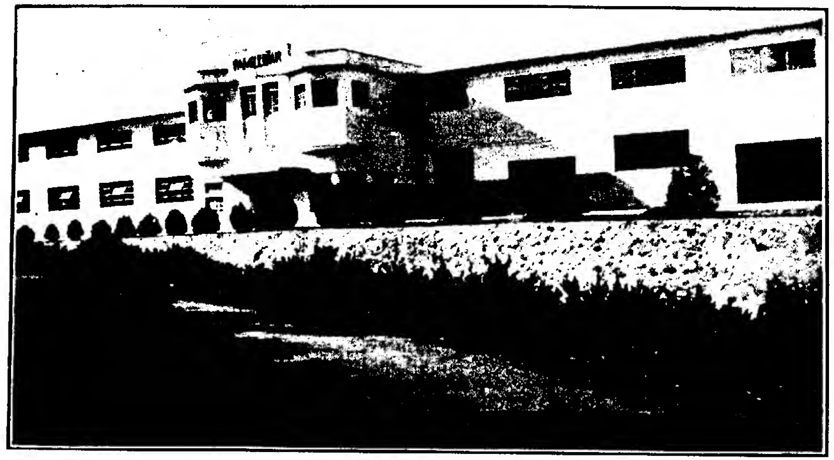
Mosquito in Java attacks at any time, but generally in February and March, at the end of the wet season. The attack is aggravated by Red rust which often completely wrecks the frame of bush just as the subsequent attack of Brown blight in India often finishes off the devastation started by the mosquito. In Java it is observed that the weaker bushes have the axillary as well as the terminal buds attacked by mosquito.

So far as the writer's observations were concerned, the ravages of the pest in Java are not so serious as those experienced either in the Dooars or the Surma Valley. True, the crop in Java may fall to *nil* when the attack develops,, just as it does in North-East India, but the bushes with their full healthy foliage do not seem so badly hit as those in India where the plucking is harder. Hard plucking has proved fatal in Java and the best general treatment for tea liable to mosquito attack is generous manuring and light plucking.

TEA MANUFACTURE.

Power and Machinery.

The tea factories in Java are run largely on hydro-electric power, and the hilly nature of the country and steady water supply are made use of to the fullest extent in this direction. In one or two cases tea is dried by air electrically heated.



Pangheljar Tea Factory, near Bandoeng, Java.
Built entirely of reinforced concrete.

The tea machinery used, like rollers and dryers, is British, as are most of the sorting machines. Individual machines are generally worked by separate motors and the absence of shafting and belting is a great advantage.

Withering

In Java, leaf is withered in lofts into which hot air passes after being bulked in a central chamber. The loft and fan arrangement is similar to that in Ceylon. Wire racks are usually employed.

The spreading of the leaf is much thicker in Java than in either Ceylon or India. Thus the Experimental Station at Buitenzorg advises that one kilo of leaf be spread on a square metre, when the racks are of wire mesh. This is about $2\frac{1}{4}$ lbs leaf to 10 square feet, just about twice the thickness suggested in India. On boards or hessian, about half a kilo and on plaited bamboo, three-quarters of a kilo of leaf per square metre is suggested.

In Java, as in India, the value of withering the leaf at low temperatures is recognised and 82°F. is the ideal suggested for the loft. A withering period of about 18 hours is advised and a loft well ventilated with fresh air.

The leaf is considered to be physically withered when it has lost from 10 to 40 per cent. of its original weight according to the initial moisture content of the leaf. Thus it is advised that leaf containing 80 per cent. moisture when it is plucked should dry till it has lost 40 per cent. of its weight. On an average, 100 lbs. of leaf are dried to about 60-65 lbs.

In India, during the Monsoon, when the leaf on the bush contains about 77 per cent. moisture and the air temperature averages 83°F., it is customary to dry 100 lbs. leaf to about 70 lbs. At the beginning and end of the season, although the fresh leaf is drier, the temperature is lower, and a fuller physical wither is given. In Ceylon 100 lbs. leaf are dried to about 55 lbs. in the "high-grown" districts where temperatures are low.

The great difference in the degree of the physical wither in the three countries is due largely to the difference in tempera-

ture, this factor being a controlling one in determining the rate of the chemical wither. In many of the low lying Java estates, temperatures are only slightly lower than those of Assam, registered during the Monsoon. However the leaf, grown under thick shade, is said to contain a greater moisture percentage than that found in India and this factor necessitates a fuller physical wither than is customary in India.

In the factories on the Pengalengan plateau, at an altitude of about 5,000 feet, withering machines invented by Mr. Bosscha, of Malabar Tea Estate, are used. The machine consists essentially of an octagonal cage about 10 feet long, each side of the octagon being about 20 inches long, with a central arrangement for blowing in hot air.

Leaf, after being physically well withered on the racks, is placed in the withering machine, one face of which acts as a door. Enough to serve one roller constitutes a charge and the leaf is then submitted to a hot air blast at about 120°F. for about 30 minutes, whilst the machine rotates at about 35 revolutions per minute. At the end of half an hour the door of the machine is opened and, as the machine continues to revolve, the leaf is flung far out and thus cooled. The leaf loses 3 to 4 per cent. moisture during the process, becomes limp and takes on a reddish brown colour and a strong smell of apples.

It is claimed that these machines make the wither regular and reduce the time of fermentation from six or seven hours to two or three hours.

Only one Bosscha Withering Machine is in use in North-East India, in a garden in the Surma Valley. Here it has been found that the best results are obtained when the machine makes about 15 revolutions per minute and, by its use, the fermentation time is reduced from three hours to three-quarters of an hour. It has been noticed that the amount of red stalk in teas thus treated is less than with untreated leaf.

It will be understood that the Bosscha Machine deals with the chemical rather than physical processes of withering.

In Java, the rollers revolve slowly, making only about 40-50 revolutions per minute. The second roll is sometimes carried out in rollers revolving somewhat faster than in the first roll, the idea being that slow rolling preserves the " tip."

Rolling.

The rolling period, on the average, is not nearly so long as in Ceylon, where it may last three hours for the fine leaf, nor is the leaf submitted to so many revolutions as in India where the rollers make 60 or even 70 revolutions per minute.

In most fermenting rooms some modern form of humidification is used. Most of the humidifiers are of the scent-spray, in which cooling and humidification of the air are carried on at the same time. A relative humidity of 95 per cent. is aimed at, since higher values than this result in deposition of moisture if a fall of temperature occurs. The need for a plentiful supply of fresh air in the fermenting room is recognised.

Fermentation.

Leaf is thinly spread for fermentation and in the gardens of high elevation and low temperatures the fermenting room is sometimes warmed.

Firing is usually carried out in one process in about 15-20 minutes, at temperatures varying from 175°F. to 212°F. although the lower temperatures are preferred.

Firing.

Wood and, in a few cases, oil are used for firing. At Malabar Estate the firing is done electrically, and it was found that, during the earlier trials, the power consumed by a large E. C. P. machine was as much as 160 kilowatts. After the stove of the dryer had been rebuilt and the leaks in the body of the machine stopped to avoid all unnecessary air loss, the required power was then reduced to about 110 kilowatts.

In Java the firing machines are lagged or insulated by plates of itanit, eboloiet or makinit, leaving about a foot of air round the stove and the air ducts. These insulating materials are of the patent asbestos-compound type, the first kind being a thin

sheet and the other two thicker, and able to stand more rough useage. The insulating sheets are built on light iron frames in a manner which makes it easy to remove them for cleaning or examining the machine.

By insulation, the fuel consumption for firing has been reduced by as much as 40 per cent.-on many gardens. Taking a conservative estimate of the economy at 25 per cent. of the fuel consumption, the annual saving in North-East India would be about Rs. 10 lakhs reckoning on a crop of 320 millions, and assuming that it takes one maund of coal costing one rupee to fire a maund of tea. The cost of insulation is about half the saving in fuel cost during one year.

All stoking of the dryers is done outside the factory and this precaution against dust and untidiness, is in keeping wih the general cleanliness of the Dutch tea factories.

Sorting.

The sorting rooms are kept scrupulously clean and free from dust. Above each sorting machine are air ducts which remove fluff and keep the atmosphere clear. The result of this is that the Java teas are generally cleaner than India teas, a necessity to teas selling largely on appearance.

Most of the sorters used in India are seen in Java. One interesting sorting machine is made by the firm of Assendelft de Coningh of Soekaboemi, combining the rotary sieve for broken grades and the reciprocating sieve for leaf grades, of which Java makes a big percentage.

Java teas are packed containing 7-8 per cent. moisture. This percentage, as the result of many experiments, is considered to be the best. A somewhat lower figure, *viz.*, 6 per cent., is aimed at in India. This percentage is considered to be a safe one if teas are to be kept for any length of time without risk of "going off."

On some Java estates, the moisture is estimated by means of a simple apparatus whereby a weighed amount of tea is warm-

ed with xylol. This substance distils together with moisture from the tea, and both are condensed into a small measuring cylinder in which the amount of water, sinking to the bottom as a separate layer, is read off. The estimation is somewhat simpler than that employed on gardens in Assam since it involves only one weighment.

General.

The tea factories in Java are finer than those in India so far as arrangement and order are concerned. The freedom from dust in the sorting room and the general cleanliness in the firing and rolling rooms are matters for remark. The methods employed in manufacture resemble those of Ceylon, so far as fullness of wither, slow rolling and firing by a single process are concerned.

Java Teas.

Java teas are well made and clean, and the leaf is black with plenty of twist as opposed to the greyish or brownish flaky teas of North-East India. The grades are similar to those in India although as much as 60 per cent. B. O. P. may be made.

Java teas lack flavour and the liquors are coloury but soft, lacking in strength. There is little " tip." The quality period in Java is from mid June to mid October, the dry season, when a little flavour is noticed. For the rest of the year the teas are common and plain. Even the high grown trees show little flavour although they are brighter and brisker than the low grown. The poorest months are from November to April, the wet period.

The Java tea prices are lower than those of India and Ceylon and it is instructive to consider some of the reasons accounting for this differences.

First, the climate is against true quality periods such as we get in India, for there is no season comparable with the cool, dry spring and autumn experienced in North-East India when leaf grows slowly and a good natural wither is obtainable.

The method of plucking in Java is not conducive to quality for, in addition to the leaf being coarse, the plucking is long.

In Assam it is found that, for quality, the leaf must be plucked not only fine but also close, and our best teas come from places where the plucking is to the *janum* or " fish leaf."

The manufacture of *kampong blad* (village leaf) also lowers the average quality of Java tea. In the Kandy area of Ceylon, the quality of the tea is similarly reduced by the manufacture of village leaf. On some gardens *kampong blad* is so coarse that it is rolled lightly for a few minutes and then sifted in a coarse rotary sieve to remove the very big, hard leaves. All the rough tea fibre and much of the stalk is sold as Bohea and the amount of this grade may be as much as 10 per cent. but usually varies between 3 and 6 per cent.

In addition to the influence of the leaf on the quality of the tea, there is also that of the method of manufacture. Java leaf does, from North-East India standards, appear to be chemically overwithered. The result of this, is a tea with a soft liquor.

It is usual in Java for tea planters to say that quality is not *in* the soil or the district, just as planters do in the poor quality districts in India. So far as North-East India is concerned, it has been shown that good teas, above the average price, can be made in any district and on any soil provided the plucking is close, fine and regular, but whether it is sound to make good teas by this means at the expense of crop and labour is an economic and not a scientific question.

VEGETABLE PARASITES OF THE TEA PLANT.—(*continued.*)

BY

A. C. TUNSTALL.

Blights on the Stem

In recent years considerable progress has been made in the investigation of diseases of the tea stem.

These diseases may be divided into two groups :—

1. Those which are apparently the direct result of infection by vegetable parasites.
2. Those in which the vegetable parasite is secondary to other causes.

Messrs. Watt and Mann describe four diseases belonging to the first group, namely, Thread blight, Canker, Horse hair blight and Darjeeling Stem blight. The only other stem disease, Red Rust, they describe belongs to the second group. In the following pages the diseases belonging to the first group will be described individually. Those belonging to the second group will be divided into two sub-divisions :—

1. Diseases due to general debility.
2. Diseases due to special conditions.

The practical treatment of the diseases belonging to each of these sub-divisions will be described generally.

STERILE MYCELIUM.

Thread blight; Wither blight.

Refs :—Watt and Mann, "The Pests and Blights of the Tea Plant," 2nd ed., p. 392.
Butler, "Fungi and Disease in Plants," p. 456.
Petch, "Diseases of the Tea Bush," p. 73.
Indian Tea Association, "Notes on the Spraying of Tea," Revised Edition, 1925, p. 29.

Found in all tea districts.

History.—This disease was first reported in 1868. The spore form of this disease has never been found on tea and it is therefore impossible to give it a scientific name. The name given by Watt and Mann *Stilbum nanum*, refers to another fungus which is frequently found as a saprophyte, sometimes alone or in association with other fungi. Thread blight occurs on Coffee in Java and jungle plants in Ceylon. In India it is also found on plants other than tea, *e.g.* bamboo, the *Utengah* of Assam (*Dillenia Indica*), the Mango and Daranta, many palms and other jungle plants.

Description.—The fungus develops white strands of mycelium like threads from which the fungus receives its name. These threads grow along the branches and spread out to form a white felt on the under surface of the leaves. The diseased leaf turns brown after some time and usually dies. It remains attached to the bush by the fungal threads. All the leaves on a bush may be killed ultimately. The threads and the films of the fungus can be peeled off from the stems and leaves when wet without difficulty.

Apparently the fungus does not produce spores but is probably propagated by dead infected leaves and twigs, blown about by the wind. It thrives best in damp shady places and may be found throughout the year on old unpruned stems. Watt and Mann observe that "The fungus itself in the ordinary thread like form in the woody parts of the bush, consists in a number of very thin strands which are attached to and draw their nutriment from the stem. Wherever they go there is an internal mycelium just under the bark and the branches are ultimately killed by the choking of the vessels in the exterior of the "Cambium zone" (that is just under the bark) by the "mycelium of the fungus." The fungus has not been observed to penetrate the leaf tissues but mycelium was found in the external tissues of the old stems just outside the cork layer and especially in the original mechanical tissue outside the phloem element which is dead and functionless. The writer has not observed the mycelium of this fungus in the living cells under-

neath this layer (cork layer). But Petch says "Hyphae from the cord penetrate into the stem, and though they do not appear to injure the tea stem, open wounds or cankers are formed on the stems of jungle shrubs. Young stems are killed by this Thread blight." Butler adds "On the petiole and green part of the stem, the strands are . . . . entirely superficial. Lower down, however, the fungus enters the tissues of the stem. This commences sometimes immediately after cork formation begins. The outer cells of the cortex, external to the cork cells dry up and are readily penetrated by the hyphae. Branches pass down through the cork layer which is not continuous when first formed and accumulate in the cortex below the young cork. The result is the gradual destruction of all the tissues external to the hyphae. The outer bark splits in longitudinal strips which at first gape then roll up and separate off. New cork is formed deeper in and the process is repeated until the bark is often entirely destroyed and the wood exposed. The hyphae have been traced as far as in the cambium."

The fungus is characterised by the presence of special bodies known as anchor cells on the thread. The central portion of these cells may be oval or spherical; but portions of the cell wall project giving the cell an anchor-like appearance. The presence of appressorial layer is also a conspicuous feature of this blight. In this respect it resembles Black rot (see below). Thread blight most probably belongs to the same class of fungi, the Basidiomycetes, to which the fungus which causes Black rot belongs.

There are a number of fungi which have the same general appearance as Thread blight but these are not parasitic and differ from the above in not having the anchor cells which are found in the parasitic species.

Depredations.—This is one of the commonest diseases of the tea stem. With improvements in pruning this disease has ceased to be a serious menace to the industry. It is however very prevalent during the rainy season on most gardens

of Cachar and Sylhet especially in narrow shaded bheels between teelas.

Remedies.—The fungus thrives best in damp shady places. If the shade is reduced and the infected stems exposed to light and air the disease usually disappears of its own accord but sometimes it is necessary to either prune out the infected stems or spray with Lime sulphur solution immediately after the usual pruning. It has almost disappeared from districts where stick pruning is generally adopted.

The most satisfactory treatment of bushes attacked by Thread blight is as follows:—

1. Improve drainage.
2. Remove excessive shade.
3. Clean prune.
4. Burn prunings.
5. Spray with Lime sulphur solution (see I. T. A. Quarterly Journal, Part IV, 1926), immediately after pruning.

Corticium Spp.

Refs:—Butler, "Fungi and Disease in Plants," p. 429.
Petch, "Diseases of the Tea Bush," p. 66.
Indian Tea Association, "Quarterly Journal," 1917, Part III, p. 80; 1918, Part III, p. 70; 1923, Part III, p. 86 and 1925, Part II, p. 53.

Corticium invisum, Petch.

BLACK ROT.

Found in all districts.

History.—The disease was not recognised in North-East India before 1914 when it was found on a garden in Cachar. It is however probable that the disease described by Messrs. Watt and Mann as "epidemic Grey blight" was identical. The first serious outbreak was observed in Assam in 1918. It is now very

widely distributed. In some districts few gardens are entirely free of it. It was at first assumed to be caused by the fungus that causes a similar disease in Java and Ceylon. This fungus was described by Dr. Bernard as *Hypochnus Theae*, the name was later changed *to Corticium Theae*. It was found however that the fungus causing the disease in North-East India differed in some important details from *Corticium Theae*, Bern., and more closely resembled *Corticium invisum*, Petch, which is found in Ceylon.

Description.—The disease known as Black rot in North-East India is very like Thread blight. It causes irregular brown patches on the leaves similar to those produced by Thread blight but no threads are visible to the naked eye. When the weather is wet the diseased leaves are often black and the younger ones become rotten and slimy. The diseased leaves do not fall off but remain attached to the stems and to each other at points of contact by a small cushion of fungus mycelium. Occasionally they may be found hanging by a tiny thread or two like those of a spider's web. The spots on the leaves are at first small, enlarging later to large, brown or chocolate-brown patches resembling those caused by Brown and Grey blights. On light coloured thin leaves the spots are frequently light in colour with a dark margin.

The fungus mycelium is wholly external and confined to the green portions of the plant. Under ordinary conditions it is invisible but if a diseased shoot be kept in a moist chamber for a few days the fungus may grow sufficiently to be visible as a white or cream-coloured weft on the surface of the leaves, forming a cobwebby mass in the axils. The mycelium is many septate and much branched, at first colourless, becoming cream-coloured with age. The disease spreads much more rapidly than Thread blight as it produces spores freely in the rainy season.

The fructifications arise on the under surface of apparently healthy leaves. They appear as powdery white patches. The

patches are usually inconspicuous and in this respect appear to differ from those produced by *Corticium invisum*, Petch, in Ceylon. The spores are borne on short sterigmata arising from short club-shaped basidia. As a rule there are four spores on each basidium. One or more basidia arise at the end of a single hypha. The spores are ob-ovoid slightly curved on one side near the base. The size of the spores appears to vary considerably.

Depredations.—The loss caused by the disease is not at first apparent as a healthy tea bush is able to lose a lot of leaf without serious effects. The damage to the leaves often stimulates the production of new leaves and the bush may actually yield more crop for a short time. In time, however, even the most vigorous bushes suffer and go back seriously. Where the bushes are already in poor condition the loss is more quickly apparent. On some gardens very serious loss has been caused by this disease and it is obviously desirable to take steps to keep it in check wherever it is found.

Corticium Theae, Bern.

Specimens of tea shoots bearing the mycelium resembling the description of *Corticium Theae*, Bern., have been observed from time to time in North-East India but so far no fructifications have been found.

Corticium Sp. 1.

Found in all districts.

History.—During 1923 and 1924 a new disease has appeared mostly on gardens bordering the Hymalayas. This is caused by another species of *Corticium* somewhat resembling that which causes Pink Disease of rubber, *Corticium salmonicolor* B. and Br.; but differing in some details. For instance: the spores differ from those of *Corticium salmonicolor* B. and Br.

Description.—The fungus attacks the brown bark of the young wood, bleaching it. The dead strips of bark on the outside of this wood are usually unattacked and in consequence

retain their normal colour emphasizing the whiteness of the bleached areas beneath. The fungus usually starts at forks on the young woody stems and spreads thence until the whole of the brown bark is bleached, it then sometimes extends to the bark of the older stems but so far has not been found on the green shoots. On account of the whitening of the bark produced by this fungus the name *Corticium dealbans* has been suggested.

The fructifications are white or pinkish patches 1/8 inch to ¼ inch in diameter usually produced just below forks on the younger brown twigs. The basidia are long club-shaped bodies bearing two or four sterigmata at the end of which the spores are produced. The spores are oblong and colourless.

Depredations.—The fungus apparently causes little immediate damage on vigorous tea bushes but wherever conditions have been unfavourable to the tea plant it has caused serious loss. The tea at Tocklai was infected accidentally from specimens received from the Terai. In the course of a few weeks the whole area was infected, not a single bush escaped. The fungus fruited freely within two months and ample material was readily available for study. In spite of this general infection the tea remained vigorous. After pruning, the prunings were burned and some time later the whole area was sprayed thoroughly with Lime sulphur solution with the exception of a small area treated with Burgundy mixture Both fungicides were effective and the disease disappeared from all the bushes with the exception of about half a dozen. These have been left untreated for a year so that the further progress of the disease may be observed on them. Although these bushes were distinctly behind the others and a few of the weaker stems have died back they were far from becoming moribund. By the end of the year many of the remaining bushes were reinfected. Thorough spraying with Lime sulphur solution after pruning has now eradicated the fungus.

Corticium Sp. 2.

During the investigation of *Corticium Sp. 1* another *Corticium* was frequently found on dead twigs on the same bushes.

This *Corticium* forms fructifications somewhat larger in area than those of the parasitic species. They are white patches bearing basidia twice as long as those of *Corticium Sp. 1*. The spores are the same but twice as broad. It is obviously quite a distinct species. It appears to be purely saprophytic.

Other species of Corticium.

Besides the abovementioned species there is another species in Cachar and Sylhet. This species kills patches of bark, causing cankerous growths. So far no satisfactory fructifications have been obtained but from other characteristics it is probably Pink Disease, *Corticium salmonicolor* B. & Br. It is not very common.

Remedies.—The treatment of *Corticium Spp* :—The species of *Corticium* which is doing the most damage is undoubtedly that which produces Black rot. This species is fortunately wholly external and one thorough application of Lime sulphur solution is sufficient to kill it right out. Unfortunately it is impossible to spray large areas quickly and if the disease becomes general it is impossible to do much until the tea is pruned in the cold weather. If however the disease is recognised while it is still confined to small areas it is a comparatively simple matter to eradicate it. The first thing to do is to isolate the areas, because coolies, cattle, etc., in pushing their way through the tea, rub off small pieces of mycelium, to say nothing of spores, and carry them to uninfected areas. A few lines of apparently healthy bushes should be included in the isolated area. If the outbreak is on a small section it is as well to isolate and treat the whole section. Next spray the bushes thoroughly with Lime sulphur solution commencing operations on the healthy tea round the edges. In the case of a number of outbreaks occurring simultaneously treat the small scattered areas first. If there is any doubt about the thoroughness of the spraying this operation should be repeated as soon as possible. No manurial or cultural treatment is effective against this species. It is necessary to apply direct fungicidal treatment.

The other important species is the one I have referred to as *Corticium Sp. 1*. In this case the fungus is within and between the cells of the bark and to be effective it is necessary for the spray fluid to penetrate this layer. Fortunately wherever the fungus has attacked the bark the latter is rendered much more permeable and there is no doubt that the Lime sulphur solution penetrates to a sufficient extent to kill at any rate most of the fungus if the fluid be used in sufficient concentration.

The most feasible method of treating this disease is to postpone operations until after the pruning. A smaller quantity of solution is then required and further the solution may be used more concentrated. As the fungus is within the tissues and there is no evidence to show that it cannot survive for a considerable time on prunings it is desirable to burn prunings within a reasonable time of pruning. From our experience at Tocklai it would appear that one application of sufficiently strong Lime sulphur solution thoroughly well applied in the cold weather after pruning is sufficient to keep the disease in check. In addition to the special treatment described above, attention to the general health of the bushes on infected areas will be well repaid. In this connection the experience of one garden may be quoted. For some years climatic conditions have been very unfavourable on this garden and in 1924 the crop fell 50 per cent. below normal. It was then discovered that the garden was badly attacked by this disease. Owing to difficulties in water supply it was impossible to carry out any spraying operations in 1924 cold weather and under these circumstances it was decided to see what could be done by taking special care in the cultivation and pruning. Under favourable weather conditions the tea responded very satisfactorily. In spite of the fact that every bush was badly attacked by the disease the bushes looked remarkably well. It must not be assumed from the above that this disease can be kept in check without spraying but the loss due to the disease may be considerably reduced by attention to the general health of the bushes. The strength of the Lime sulphur solution sug-

gested in Quarterly Journal, Part IV, 1926, p. 161, has been found satisfactory.

Nectria Cinnabarina (Tode) Fr.

Refs.—Watt & Mann, "The Pests & Blights of the Tea Plant," 2nd ed., p. 408.

Butler, "Fungi & Disease in Plants," p. 463.

Petch, "Diseases of the Tea Bush," pp. 94 and 103.

Indian Tea Association, "Quarterly Journal," 1914, Part II, p. 52.

Indian Tea Association, Pamphlet "A Stem Disease of Tea," 1918.

Found in all tea districts.

History.—A disease attributed to [*Nectria ditissima* (?)] was described by Messrs. Watt and Mann under the heading "The Tea Canker." It has been found subsequently that the tea canker is only occasionally associated with *Nectria Sp.* Disease caused by *Nectria Sp.* however is found in all the North-East India tea districts. It is however only common in Darjeeling and the districts bordering the Hymalayas.

For many years it had been noticed in Darjeeling that the tea in the neighbourhood of certain trees, notably Utis (*Alnus nepalensis*) and Umphi (*Pyrularia edulis*), was frequently unhealthy and it was thought locally that the trees in question secreted some sort of plant poison. It was apparent that the ill-health of the bushes could not in many cases be ascribed to anything connected with the roots of the Umphi or the Utis trees as often fairly deep ditches separated the tea from the trees in question. Nor was the damage confined to the area under the shade or the drip of the trees but seemed to be determined to some extent in the case of fresh outbreaks by the direction of the wind. On some gardens it was found that *Erythrina Spp.* were centres of infection.

On investigation it was found in 1916 that the unhealthy tea was attacked by a fungus, *Nectria Cinnabarina* (Tode) Fr. For a long time however the connection between the fungus on the tea and the trees associated with its occurrence was obscure. It was eventually discovered that the same fungus attacked the flowering shoots of the trees in question.

Description.—The fungus attacks the bark of woody stems and the growing layers (between the bark and the wood) and spreads from them down the medullary rays into the pith. The wood is not at first attacked. The fungus does not kill the growing layers at once but gradually starves the infected stems which become moribund and after some months in that state frequently die. The fungus is generally present in the tissues of the plant some distance below the portion obviously diseased. On the death of the shoot, sometimes before, the fruiting stages are produced. These are easily found. They are produced on the bark of the stems. The most noticeable are pink cushions about 1/32 of an inch across which are usually produced in profusion. These are called conidiospores and consist of a mass of fungal hyphae or threads arranged together with their ends outwards. The end of each hypha swells slightly and a wall grows beneath the swelling. The swollen end then becomes detached, forming a spore. These spores are called conidiospores, and the cushions in which they are borne, conidiophores. Along with the conidiophores another form of fructification is produced —a number of dark red spherical bodies of about 1/40—1/50 inch across. These are produced singly or in groups, sometimes attached to the conidiophores, but more often separately. Examination of these with a lens shows that they have a small cone-shaped aperture. The cone-shaped portion collapses slightly in old ones. A more careful examination with a microscope reveals that these bodies are protected by hairy out-growths sometimes minutely roughened. These bodies contain a large number of sausage-shaped sacs each containing eight two-celled spores. The walls of the spores are often minutely striated.

These spores measure 10—15 by 5μ.* They are called ascospores. The sausage-shaped sacs are asci (Sing. ascus) and the spherical cases perithecia (Sing. perithecium). Still another form of spore is produced. They are long narrow ones measuring 37—67 by 3—3.5μ,* and are called fusarium spores from their shape. They are sometimes found on loose tufts of hyphae round about the perithecia and conidiophores.

The fungus was grown in pure culture from all three kinds of spores and also from mycelium found in the wood and bark of infected tea branches.

It was most successful on maize meal agar and cane sugar agar. The colour in all cases was white or pink. The conidiophores appeared in 6—8 days but the perithecia were very much later.

On sterilised tea stems the perithecia formed more quickly. Fusarium spores were produced freely in all the cultures.

Inoculations with both mycelium and conidiospores were carried out on tea bushes growing at Tocklai and were successful on wounded shoots but not on undamaged ones. From this it may be inferred that the fungus is a wound parasite. It should however be pointed out that the climate of Tocklai is so different from that of Darjeeling that it does not necessarily follow that the fungus cannot infect undamaged shoots in the latter district In any case there would be ample opportunity in all districts for the fungus to gain access to the plants, as plucking, of necessity, causes wounds and our experiments at Tocklai prove that such wounds can be infected.

Depredations.—The bushes attacked by this fungus become moribund but rarely die right out. The stems die back and the new shoots which arise lower down are generally thin and weakly. In a few cases healthy shoots break away from the collar but these quickly become moribund. The general appearance of the bushes is similar to that of tea very badly attacked by Red

* μ = 1/1000 of a millimeter.

rust. In a few cases the plants form callosities on the stems in an attempt to repair the damage done by the fungus. These are not however characteristic of the particular disease as they are caused by many agencies.

The damage done by the disease was considerable, especially on some gardens where Utis trees had been planted as wind-breaks.

Remedies.—It is necessary first of all to remove trees known to harbour the fungus. This is often difficult but as the spores do not seem to travel very far it only appears to be necessary to remove these trees in the neighbourhood of the tea.

The diseased bushes should be pruned to good wood in the cold weather and sprayed with a fungicide immediately after pruning in order to protect the cuts from possible infection. The prunings should all be burned on the spot at once.

In some cases where it has been desirable to preserve Utis trees as a wind-break in the neighbourhood of the tea it has been found possible to prevent serious infection with this disease by spraying the sections in the vicinity of the trees with Lime sulphur solution immediately after pruning.

METEOROLOGICAL OBSERVATIONS IN ASSAM, 1927.

By

C. R. Harler.

The 1927 Season in Assam.

The 1927 season in Assam was, on the whole, a poor one. The early months were unfavourable because the soil was wet and cold, resulting in poor nitrate prduction. April was also a cold, wet month during which the early flush grew slowly and rim blight developed.

So far as the end of the season was concerned, September was cool and October dry, the latter owing to bad distribution, although the rainfall was above the average for this month. Both months were rather unfavourable. In November the weather improved but these conditions came too late to insure a good back end. The maximum and minimum temperatures of the latter part of the season are shown below in comparison with the average.

	September.		October.		November.		December.	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
Average for past 8 seasons	88	75	84	70	79	59	73	51
Season 1927	86	72	85	68	79	57	73	48

The two seasons of recent years showing remarkably good closes were 1919 and 1924, both years exhibiting high minimum temperatures in October. In 1919 the average minimum for this month was 72°F and in 1924 it was 73°F. This factor must be regarded as an important one in determining late crops.

Further mention must be made of rim blight, the disease which attacked the bushes first in April and continued to do so with such vigour, that the plucking had to be lightened. This disease was apparent, although in a form less virulent, in both 1926 and 1925. The initial appearance followed on heavy pruning in 1925. It was noticed that the light leaved varieties suffered most whilst the dark leaved were relatively free.

The 1927 season was not a good one for wood and the pruning in the cold weather showed much die-back and many snags.

The total rainfall at Tocklai was 93.28 inches, considerably above the average, partly owing to copious falls in September which were largely responsible for the low temperatures recorded in that month.

Table showing rainfall at Tocklai, in inches.

	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
Average 10 years	1·00	1·56	3·62	8·69	9·16	12·90	16·72	13·30	10·79	4·61	0·90	0·33	83·0
1927	1·40	3·44	3·85	9·78	4·64	17·12	13·85	15·66	16·90	5·87	0·74	*nil*	93·2

The feature of this table is the February rainfall which kept the soil wet and cold.

The Monsoon may be said to have ended on October 16th when a fall of 3.66 ins. of rain was recorded. This termination with a heavy fall is often the case and is probably due to the fact that the south-west moisture laden wind, instead of proceeding to the Himalayan slopes to deposit its moisture is brought to a standstill and forced to higher, colder regions by the north-east Monsoon which has commenced to blow. After these heavy falls there is generally a complete reversal of wind direction and a fall in temperature and humidity.

SUNSHINE.

Sunshine records are now kept at Sylee in the Dooars, and at Doom Dooma in addition to Tocklai. The records from March onwards for 1927 are as shown below.

HOURS OF SUNSHINE.

	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Tocklai	179	191	193	171	147	154	138	209	189	170
Doom Dooma	105	135	166	141	144	154	99	169	195	202
Sylee	190	217	216	144	114	149	144	223	186	142

So far as the available records go, March, April and May were sunnier months at Sylee and Tocklai than in either 1926 or 1925. No Doom Dooma records are available previous to

1927. At Sylee, in the year under review (1927), August showed 149 hours' sunshine against 127 hours in 1926 and 96 hours in 1925. August is an important month in connection with mosquito blight and long hours of sunshine at this period usually go with a light attack.

The term sunshine indicated above connotes bright light of varied intensity and composition. The importance of "light" as a biotic factor has long been recognised by all investigators of plant growth, but it is realised that the measurement of the darkened streak, left by the sun's rays on the sensitized paper used in the ordinary sunshine recorder, is a very inadequate measure of "light." The region of the spectrum which constitutes "light" from the ecological viewpoint is greater than the visible spectrum sensed by man. The larger spectrum includes the region in which the energy curve of sunlight is at a maximum, it includes the red region which assists in plant photosynthesis, it includes the blue-green region which is most effective in phototaxis (movement towards light) in plants and the ultra-violet region which produces sunburn and tanning. Both the ultra-violet and the infra-red region (that first mentioned) are invisible to man. The ultra-violet region forms part of the visible spectrum of many insects.

Certain instruments of high precision can be used for measuring, in some detail, the radiation from the sun. With a Nutting Polarization Spectrometer the following interesting observations were made.

In full sunlight the different parts of the spectrum were in the following ratio—

Orange—3,278, Green—819, Blue-Violet—131.

In the shade of a single white spruce the ratios were—

Orange—13, Green—27, Blue-Violet—38.

In a fairly dense spruce-ceder wood, the ratios were—

Orange—1.2, Green—2.7, Blue-Violet—4.0.

A series of measurements made in the open on a hazy day gave the ratio—

Red—206, Yellow—365, Green—3,278, Blue—3,278.

These data show quite clearly the blue quality of the light in shaded areas and the blue-green nature of the light on a hazy day, as compared with the red-yellow quality of direct sunlight.

These facts are of interest in connection with tea problems. Thus, in some years shaded areas are mosquito attacked and unshaded areas free or less vigorously attacked, whereas in other years the reverse holds, and a study of the nature of sunlight in different seasons would probably give interesting information.

In connection with the quality of sunlight, it is interesting to observe that, in India, our vegetable gardens suffer from the late afternoon sun and not from the early morning sun. The afternoon sun sunlight appears to contain a bigger proportion of red-yellow light than the morning sun sunlight. So far as tea is concerned, it is common experience in the Surma Valley for the western slopes of a *teela* to carry poorer tea than the eastern slopes and here, no doubt, the quality of the sunlight has some influence.

TEMPERATURES.

The maximum and minimum air temperature, solar and terrestrial radiation and soil temperatures were taken as usual. There is nothing particular to report in these connections.

No comparative temperature figures for the Dooars have been available until recently because maxima and minima have usually been taken on bungalow verandahs. These values are not comparable with those taken under standard conditions by thermometers placed in a regulation louvred box. A thermometer box has now been installed at Sylee in the Western Dooars. Previously, the temperatures of Jalpaiguri have been taken as indicative for the Dooars, but the difference must often have been considerable seeing that this place is about 40 miles from the hills where the main tea areas are situated.

THE WEATHER CHART FOR 1927.

The weather chart is drawn upon lines indentical with those of the last few years. The top curve which indicates soil mois-

ture shows the soil condition to have been much wetter during the early part of the season than during 1926.

The monthly average soil moisture for 1926 and 1927 is shown below. The soil condition in January and February largely accounted for the poor start. At Borbhetta during March, 1927 the soil nitrates seldom rose above three parts per million, against about ten parts in the average year. This difference is accounted for by the cold, wet state of the soil.

SOIL MOISTURE AT TOCKLAI.

	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1926	11%	10%	16%	14%	17%	17%	19%	19%	18%	18%	15%	13·7%
1927	15%	15%	15%	18%	18%	19%	19%	19·5%	20%	19%	16%	13·3%

The second curve on the chart denotes the average daily windage in miles. The only peculiarity here is the low value for December when the average mileage was only nine against a normal value of 16.

The crop curve is that of the Tocklai clearance, an area of about 2½ acres consisting in plots of Kalline, China, Kharikatia Singlo, Betjan and Panighat jats. The curve of the total crop shows the poor early crops and the big flush which came in June, after the soil warmed up. The subsequent drop in crop is partly the wake of the first flush and partly due to the leaving of a leaf before the next flush.

The curves *A* and *B* denote the areas cut to 24 inches and 16 inches respectively. The higher cut bushes are pruned annually and hence on one year wood. The *B*-areas are cut biennially on two-year wood. The difference between the crops is not so great as would be expected largely owing to the fact that the whole area was lightly plucked the previous year. Then it was observed that light plucking lost more leaf from the unpruned (biennially pruned) area than from the annually pruned area. The unpruned tea was therefore more spared than the pruned and hence gave more than would be expected normally from tea cut on two-year-old wood.

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